ARCTIC

VOLUME 3, NUMBER 3 · DECEMBER 1950

OHIO STATE

JOURNAL OF THE ARCTIC INSTITUTE OF NORTH AMERICA

THE ARCTIC INSTITUTE OF NORTH AMERICA

Officers and Staff
1950

Chairman
RICHARD FOSTER FLINT

Vice-Chairman
H. L. KEENLEYSIDE

Secretary
M. J. DUNBAR

Treasurer
JOHN C. REED

Executive Director
A. L. WASHBURN

Director, Montreal Office
P. D. BAIRD

Director, New York Office
WALTER A. WOOD

Editor of the Institute Journal *Arctic*
DIANA ROWLEY

Board of Governors

D. W. BRONK, Baltimore, Md.
C. H. D. CLARKE, Toronto, Ont.
M. J. DUNBAR, Montreal, Que.
RICHARD FOSTER FLINT, New Haven, Conn.
ERNEST GRUENING, Juneau, Alaska
A. D. P. HEENEY, Ottawa, Ont.
H. L. KEENLEYSIDE, Ottawa, Ont.
T. H. MANNING, Ottawa, Ont.
EJNAR MIKKELSEN, Charlottenlund, Denmark
J. J. O'NEILL, Montreal, Que.
JOHN C. REED, Washington, D.C.
FINN RONNE, Chevy Chase, Md.
G. W. ROWLEY, Ottawa, Ont.
EDWARD H. SMITH, New York, N.Y.
R. E. STAVERT, Montreal, Que.
A. L. WASHBURN, Montreal, Que.
J. TUZO WILSON, Toronto, Ont.
WALTER A. WOOD, New York, N.Y.

Offices of The Arctic Institute of North America
3485 University Street, Montreal, Quebec, Canada
Audubon Terrace, Broadway at 156th Street, New York 32, N.Y., U.S.A.

ARCTIC

Journal of the Arctic Institute of North America

Vol. 3, No. 3 Published in Ottawa, Ontario **DECEMBER 1950**

CONTENTS

Cover Picture: Dog-team travelling up lower Sam Ford Fiord, end of May 1950 *(Photo: M. H. W. Ritchie)*

Baffin Island Expedition, 1950: a preliminary report. *P. D. Baird and others* 131

Photographic Operations of the Royal Canadian Air Force. *Wing Commander R. I. Thomas* 150

Observations on a Cyclic Decline of Lemmings (*Lemmus*) on the Arctic Coast of Alaska during the Spring of 1949. *R. Rausch* . . . 166

Physical Oceanography of the North Polar Sea. *H. U. Sverdrup* . 178

Recent Studies of the Lapps. *Review by Robert N. Pehrson* . . . 187

The Problem of Place Names in the Soviet Arctic. *Review by C. J. Webster* 189

Reviews 191

Northern News 191

Geographical Names in the Canadian North 195

Index 196

Arctic is published under the direction of the Board of Governors of the Arctic Institute of North America. The Institute is a non-profit organization whose object is to encourage scientific exploration and study of the Arctic.

Particulars with regard to Associate Membership in the Institute, which includes subscription to *Arctic*, may be obtained from: The Arctic Institute of North America, 3485 University Street, Montreal, Canada, or, The Arctic Institute of North America, Inc., Audubon Terrace, Broadway at 156th Street, New York, U.S.A.

COPYRIGHT REGISTERED 1950

Photo: M. H. W. Ritch

Norseman at Camp M2, Eglinton Fiord: Cockscomb, 5,330 feet, in centre.

BAFFIN ISLAND EXPEDITION, 1950: A PRELIMINARY REPORT

***By* P. D. Baird* and other members of the expedition**

THIS expedition carried out a program of geological, glaciological, and biological investigations near Clyde settlement on the east coast of Baffin Island. The coastal mountains and fiord scenery in this region are spectacular and inland there is an isolated ice cap, some 3,700 square miles (6,000 sq. km.) in area. Scientifically this region was little known. The Wordie expedition[1] explored certain of the fiords in 1934, and M. H. W. Ritchie and the writer, who were both members of that expedition, saw the ice cap at a distance. In the winter of 1940 the Rev. Maurice Flint crossed from Piling to Clyde Inlet, passing round the southern edge of the ice cap, and this journey was twice repeated in the opposite direction, by Canon J. H. Turner in the winter of 1941 and by Cst. Webster and S/Cst. Kyak of the R.C.M.P. in the spring of 1945. These three journeys were carried out in the course of other duties and detailed exploration had not been possible. The area therefore seemed very promising both for geological studies in the coastal mountains and for glaciological studies on the ice cap.

The expedition had the support and assistance of the Arctic Institute of North America[2], the Royal Canadian Air Force, the Geological Survey of Canada, the Swiss Foundation for Alpine Research, the Canadian Geographical Society, and many private sources—universities, commercial companies, and individuals.

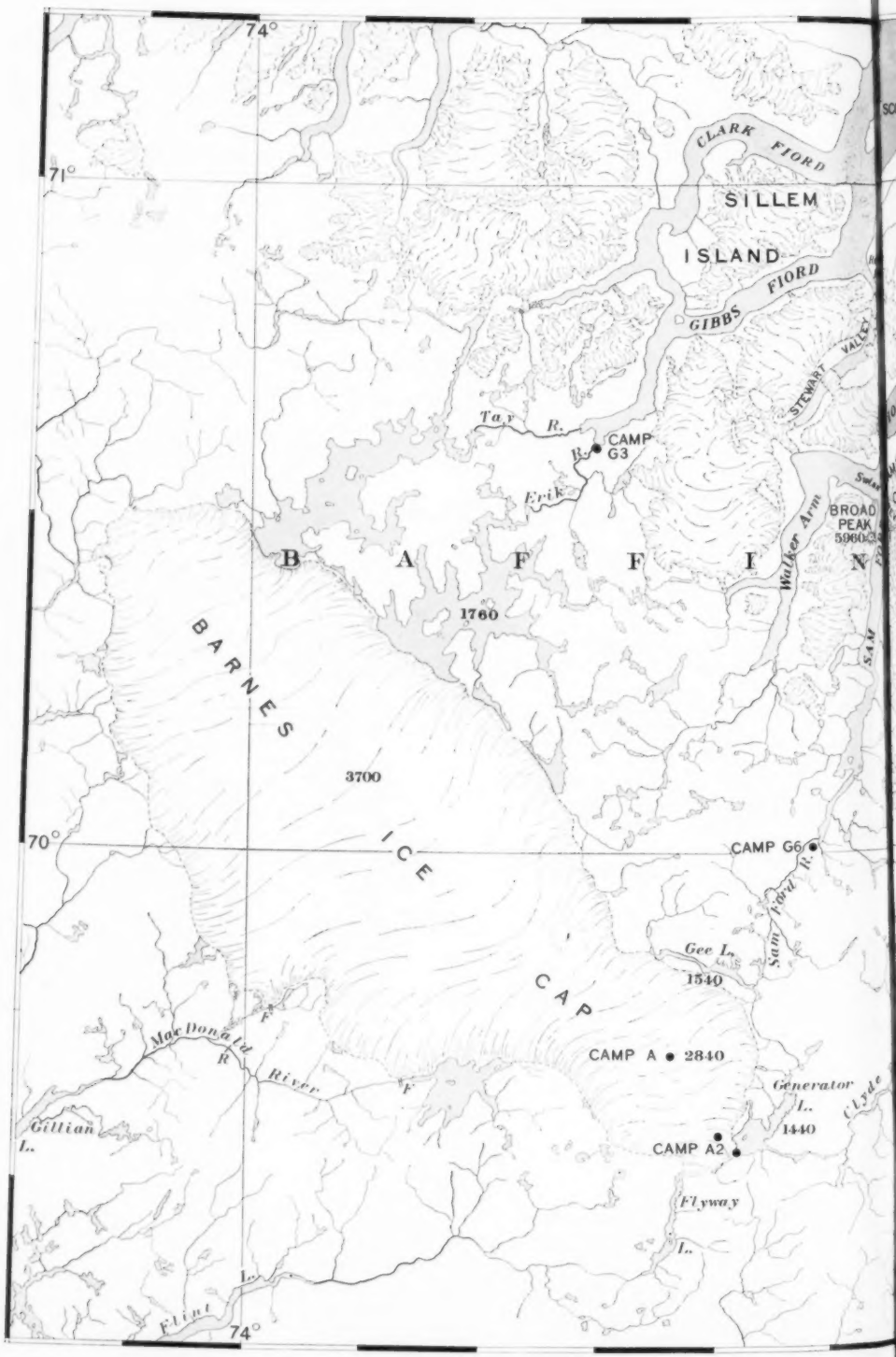
The party consisted of:

A. Anderson	Aberdeen University	Assistant Zoologist
P. D. Baird	Arctic Institute	Leader and Glaciologist
P. Dansereau	Université de Montreal	Botanist
Françoise Dansereau	Montreal	Artist and Quartermaster
K. E. Eade	McGill University	Geologist
F. Elmiger	Switzerland	Mountaineer and Physician
R. P. Goldthwait	Ohio State University	Geomorphologist
M. E. Hale	Yale University	Assistant Botanist
E. H. Kranck	McGill University	Petrologist
C. A. Littlewood	Dominion Observatory	Gravimetrist
Margaret R. Montgomery	McMaster University	Geographer
H. R. Mülli	Switzerland	Mountaineer and Mineralogist
S. Orvig	McGill University	Meteorologist
G. C. Riley	McGill University	Geologist
M. H. W. Ritchie	Texas	Photographer and Mountaineer
H. Röthlisberger	Switzerland	Mountaineer and Geologist
J. D. C. Waller	McGill University	Mechanical Engineer
W. H. Ward	U.K. Dept. of Scientific and Industrial Research	Glaciologist
V. C. Wynne-Edwards	Aberdeen University	Zoologist
J. M. King	Alaska	Pilot

*Director Montreal Office of the Arctic Institute.

[1]Wordie, J. M. "An expedition to Melville Bay and north-east Baffin Island", *Geogr. J.* Vol. 86(1935) pp. 297-316.

[2]With funds provided through the U.S. Government.


74°
71°
70°
74°
CLARK FIORD
SILLEM
ISLAND
GIBBS FIORD
STEWART VALLEY
Tay R.
CAMP G3
Erik
B A F F I N
1760
BARNES ICE CAP
3700
Walker Arm
BROAD PEAK
CAMP G6
Sam Ford R.
Gee L.
1540
CAMP A • 2840
MacDonald R.
River
Gillian L.
Generator L.
1440
CAMP A2
Flyway L.
Flint L.
SCOTT I.
COCKSCOMB Mtn.
PASS

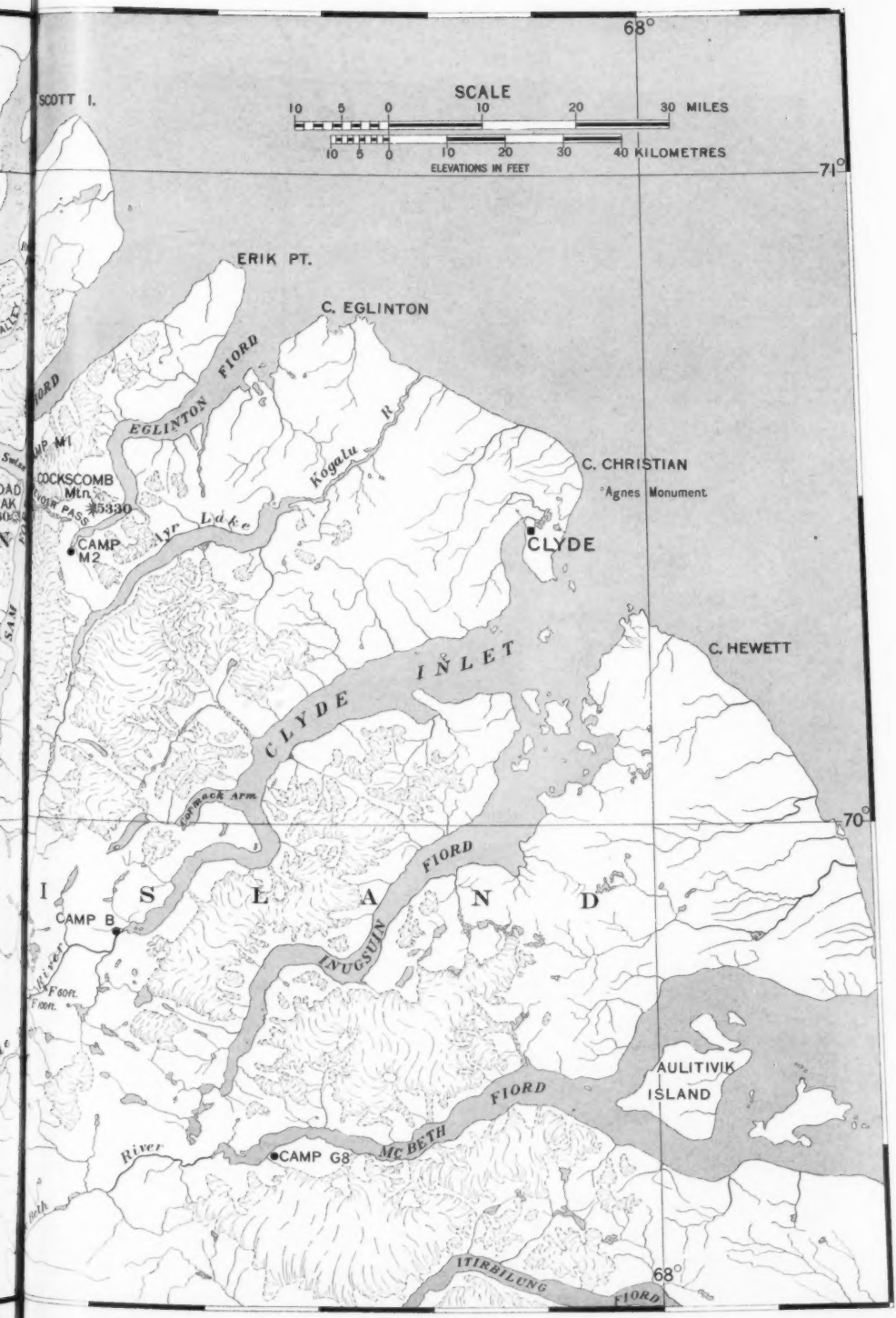

68°
SCOTT I.
SCALE
10 5 0 10 20 30 MILES
10 5 0 10 20 30 40 KILOMETRES
ELEVATIONS IN FEET
71°
ERIK PT.
C. EGLINTON
EGLINTON FIORD
Kogalu R.
C. CHRISTIAN
Agnes Monument
COCKSCOMB Mtn. 5330
CAMP M2
Ayr Lake
CLYDE
C. HEWETT
CLYDE INLET
Katsack Arm.
70°
I S L A N D
CAMP B
INUGSUIN FIORD
AULITIVIK ISLAND
FIORD
CAMP G8
McBETH
River
ITIRBILUNG
FIORD
68°

Photo: R.C.A.F.

Southeast part of the Barnes Ice Cap from the air, looking west. Gee Lake is in the centre right side and the lake from which MacDonald River flows in the left upper corner of the photograph.

For transportation in the field the expedition depended almost completely on the use of the Arctic Institute's Norseman aircraft, fitted initially with ski-wheels and later with floats. This was the aircraft which had been used on the two Snow Cornice expeditions of 1948 and 1949 (*Arctic*, Vol. 1(1948) pp. 107-12, and Vol. 2(1949) pp. 118-9) and was flown by the same pilot, Maurice King. The Norseman with King and two other members left Montreal May 9 and reached Clyde, the base of operations, ten days later. The remainder of the party went north by R.C.A.F. airlift and all arrived by May 20 in fine spring weather with the snow cover on the land just beginning to go at the sea coast.

Three main camps were established by air, each with portable radio transceivers for intercommunication. Camp A, the glaciological and meteorological station, was on the Barnes Ice Cap 100 miles inland from

the settlement at Clyde; Camp B, the biological headquarters, was at the head of Clyde Inlet; and Camp M (for the mountaineers) was first established on Swiss Bay of Sam Ford Fiord and later moved to the head of Eglinton Fiord. In addition to these main camps there was Camp A2, an important subsidiary of Camp A, which was originally situated on the southeast edge of the ice cap and later moved just off the ice cap. The geologists remained mobile, working in Gibbs Fiord, Sam Ford Fiord, and McBeth Fiord.

These camps were stocked till at least the end of July during the first thirteen days of operations. By June 4 ten tons of personnel and equipment had been moved inland in 35 flying hours, and for twenty days the aircraft was available to make two flights around the ice cap and a "mail run" to all the camps before leaving to have floats fitted at Frobisher Bay.

The ice broke up at the head of Clyde Inlet early in July but the aircraft was unable to return till July 17 owing to conditions at Frobisher. By July 19 it was possible to land at Clyde settlement where the main fuel supplies were located. Gibbs Fiord and the lakes around the ice cap did not clear until later but by the end of July all the camps had been restocked for the rest of the expedition and the geologists transported to new locations. During August two longer flights were made, the first to Lake Gillian and Bray Island near the west coast of Baffin Island and the second to Cape Searle near Padloping Island.

Photo: P. D. Baird

Swiss Bay: site of Camp M1 just to the left of the photograph.

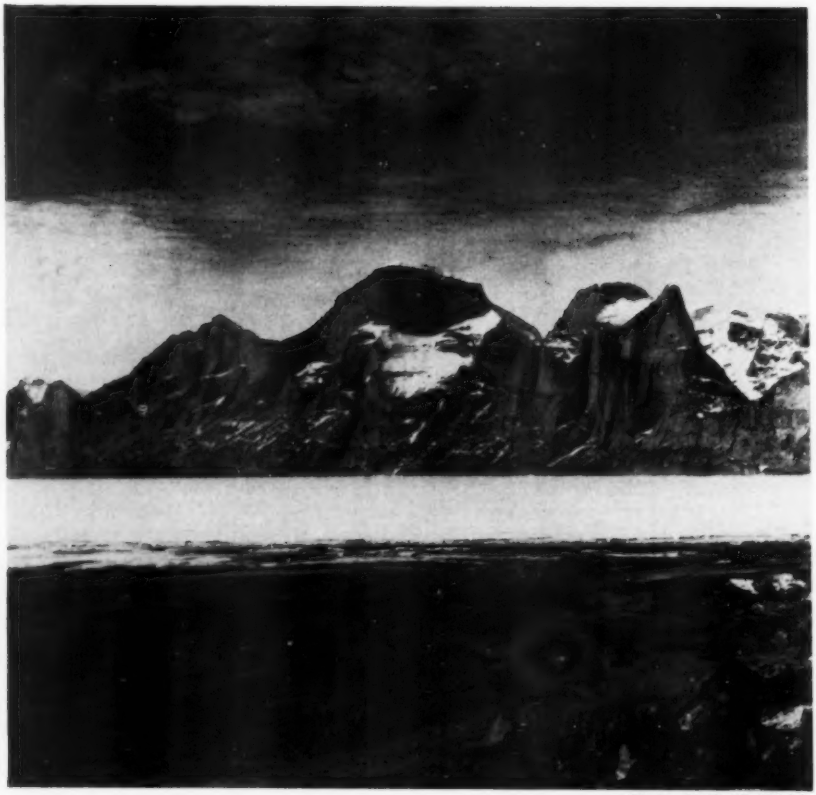


Photo: M. H. W. Ritchie

View from Camp M1 looking across Sam Ford Fiord to Broad Peak, 5960 feet, climbed 28 June 1950.

Evacuation of camps was planned to begin on September 1 but the progress ahead of schedule of the Canadian Government vessel *C. D. Howe* and an early onset of wintry conditions necessitated a change. Camp A on the ice cap was evacuated August 27 and by September 1 the whole party was back at Clyde. The Norseman and the ship both left on September 5. The former was back in Montreal on September 10, the latter reached Quebec on September 22 after visiting three posts north of Clyde and Frobisher Bay.

There follow brief initial reports on the progress of some of the scientific studies. Dr. Wynne-Edwards states that it is too early yet to report in any detail on the zoology other than to say that: (1) We collected a varied assortment of animals, especially birds, insects, and fresh water organisms; (2) we studied the breeding biology of the small passerine birds, in particular the Lapland longspur, and (3) we visited in August the fulmar colony at Cape Searle, estimating the number of birds present

Photo: M. H. W. Ritchie

Looking northwest from the summit of Broad Peak.

to be between 100,000 and 500,000. This colony had never previously been visited by scientists and may be the largest yet known.

The Swiss mountaineering group climbed some seventeen peaks, ranging up to nearly 6000 feet in altitude, including the spectacular Cockscomb (5330 feet) above the head of Eglinton Fiord. In addition they carried out geological and glaciological investigations and spent some time working on or around the ice cap.

GEOLOGICAL RECONNAISSANCE. *By K. E. Eade and G. C. Riley*

The first geological field camp was set up in Refuge Harbour, Gibbs Fiord, on May 30. The bedrock in this area consists of gneiss, as do the shores of Gibbs Fiord to its head. A few basic dykes were seen cutting both gneiss and pegmatite veins. The second camp was set up at a small island, above Sillem Island, on June 3. G3, the camp at the head of Gibbs Fiord, was reached on June 9 when work was held up by a five-day storm.

The Norseman arrived on June 17 bringing in Dr. Kranck. The break-up period was spent in making a detailed study of a section of gneiss. The weather was exceptional in this part and we encountered winds up to 70 miles per hour and there were several rainfalls of over 2 inches.

After two unsuccessful attempts, the aircraft landed on floats on July 24 and we moved to the north shore of Walker Arm. Here we started to make use of our 17-foot freight canoe, powered with a 5 H.P. Johnson engine. Moving camp by canoe proved to be difficult because of the high average wind velocity and the canoe was adequate only as long as the wind was less than 15 miles per hour. The geology of the outer parts of Sam Ford Fiord is similar to that of Gibbs Fiord.

On August 1 the party was flown from Camp M1 in Sam Ford Fiord to the head of McBeth Fiord, where a camp was set up on the south shore. Inland metamorphosed schists occur but seaward the geology of the fiord is similar to that of the more northern areas. More bad weather was experienced; one of the gusts of wind twisted the aluminium alloy pole of our Mount Logan tent into a spiral and our canoe was made unserviceable.

On August 26, after air transportation from McBeth Fiord to the head of Cormack Arm, Clyde Inlet, the last trip was begun. From Cormack Arm to Clyde settlement, which was reached on August 31, the geology is again similar to the other seaward areas.

Bedrock Geology. *By E. H. Kranck*

Bedrock surveys were made from the following base camps: head of Clyde Inlet, May 24-June 17; head of Gibbs Fiord, June 17-July 24; head of Eglinton Fiord, July 24-7; head of Sam Ford Fiord, July 27-August 2; head of McBeth Fiord, August 3-20; and at the southeast end of the ice cap, August 23-8. Investigations were also carried out around the settlement at Clyde. During flights between base camps a fairly good picture of the general bedrock geology of the whole area was obtained.

The region studied by the writer comprises parts of the coastal range with its fiord area and the interior plateau between the high mountains and the inland ice. The central parts of the mountain range and the plains along the coast consist, so far as is known, of gneiss. The foliation of the rock, often accentuated by amphibolitic sills parallel to the schistosity, is in general very flat, often horizontal. The gneisses are evidently paragneisses; mica- and garnet-rich inclusions are abundant.

In the westernmost parts of the coast range from the heads of Sam Ford Fiord and Clyde Inlet westwards, metamorphic sediments represented by marble, micaschist, and altered quartzitic schists are found. Although highly folded and faulted, they seem to form one continuous flat-lying horizon, that can, with certain interruptions, be followed westward to the ice cap. The same succession of white, glassy quartzite (lowermost) and

marble interbedded with argillaceous layers altered into lime-silicate rock occurs. Both the top and the bottom of the series consist of grey banded gneiss, or granite gneiss.

Another horizon of sedimentary schists was found at the head of McBeth Fiord. Except for a thin horizon of limestone on the north shore of the fiord, this series consists of mica-gneisses, micaschists, and quartzitic rocks invaded by granite in the form of dykes and stocks. Granites of this type were not found in the gneiss areas of the high mountains. The sedimentary schists of McBeth Fiord strike about north-west-southeast. The schists are rich in sulphides and show a strong rusty weathering.

What was evidently the same formation was found at the southeast end of the ice cap, consisting here of phyllitic micaschists and quartzitic schists. The series contains an iron formation consisting of a low grade banded magnetic ore, some 200 to 300 feet in thickness, which could be followed for about one mile. North of the iron formation, a great pegmatite dyke cutting a gabbro was found. It contains abundant tourmaline, forming crystals up to two feet in length, and some columbite.

Geomorphology. *By Richard P. Goldthwait*

The geomorphic studies aimed at discovering two things, the activity of the margin of the southern half of the Barnes Ice Cap as it related to the formation of moraines, and the glacial history of the area between the ice cap and the coast.

The ice cap is advancing on some fronts into moderately weathered drift and established plant associations. Some of this growth is by perennial snow-drift accumulation along the steep ice margins. On the other hand where there is no net snow accumulation slow retreat is producing end moraines. Along the shear planes clay till in small quantities is brought up to the ice surface, 50 to 200 feet above the ground. This material creeps and oozes down the steep ice edge as fast as it is exposed, but where it piles up to more than a foot deep on the ice toe it prevents summer ablation. At the same time the dirt sliding down the active ice above absorbs and transmits the sun's energy, thus accelerating the melting which forms a hollow between the ice-cored moraine and the dirty active ice above. Meltwater helps to enlarge this hollow in places during the summer, but also deposits sand in pools which become dirt cones in subsequent years. Ice buried as a core in the moraine becomes inactive as it is severed from the main glacier but it melts away slowly as it is exposed from time to time where slump or stream transection occur. Thus finally the moraine is "let down" in hummocks on solid ground[1].

[1]In this respect the writer and W. Ward differ as Ward identifies ice in the ground in areas surrounding the "apparent" ice edge as glacier ice. The writer believes it to be of frost-derived origin.

Photo: M. H. W. Ritchie

Diamond drill near Generator Lake (second Camp A2): ice cap in the background.

Photo: M. H. W. Ritchie

River in gorge, approximately 20 feet deep, near the edge of the ice cap.

The oldest geomorphic record is a prominent erosion surface preserved as accordant hilltops across the southwestern part of central Baffin Island. To the northeast these rise to subdued mountains near the former drainage divide. This surface was tilted highest at the extreme northeast so that peaks in this region now reach 5000 to 6000 feet in altitude. The system of dendritic and parallel valleys cut into this upraised surface shifted the drainage divide westward. The divide was shifted still farther west by intense Pleistocene glacial erosion emanating from centres southwest of the divide. High peaks so concentrated the erosion as to produce a complicated interconnected network of deep outlet valleys through the mountains. As deglaciation occurred (presumably after the last substage of Wisconsin time) the ice still flowed from the hill lands of central Baffin Island rather than from local mountain glaciers in the east (as shown by indicator rocks). Regular stages of thinning of the ice tongues are marked by many lateral moraine benches on fiord walls, and a few of these connect from the head of one fiord to another suggesting simultaneous stages. The lowest and best marked level consists of gravel kame terraces which terminate in the upper part of each fiord on a 200-foot strandline interbedded with marine silts. An association of molluscs fully as warmth-loving as those in Baffin Bay today suggests that this final great recession occurred at the beginning of the climatic optimum 4000 to 6000 years ago. As broad ice tongues retreated westward, braided streams built valley trains at the head of each fiord into seawater some 120 feet higher than today. As soon as the ice edge retreated over the watershed (nearly to its present position) marginal lakes impounded the bulk of glacial sediments, thus streams draining from each lake to a fiord became unloaded and began to dissect the outwash in meandering curves. Many stages in this dissection are evident in the cut-and-fill terraces in the valleys and continuing uplift is indicated as each terrace ties directly to one of a series of raised sea beaches in the fiord.

Glaciology. *By W. H. Ward*

The glaciological work was mainly devoted to a study of the large ice cap which lies approximately in the centre of the island and west of the fiord-mountain region. It is about 145 kilometres long in a northwest-southeast direction, up to 56 kilometres wide, and rises from an altitude of about 460 metres to 1130 metres. It appears to be a blanket of ice about 600 metres in thickness overlying rolling topography similar to the land to the west. In some places the edge of the ice cap is but a nominal one, as glacier ice covered with only about 1 metre of till or sediments extends for at least several kilometres from the apparent edge of the ice.

The whole ice cap consists of dense glacier ice, fairly evenly covered with not more than 1.3 metres of current snow, a third of which fell in

Photo: M. H. W. Ritchie

Camp A1 in June from the top of the meteorological tower.

Photo: M. H. W. Ritchie

Orvig and Ward reading temperatures at Camp A1 in rough weather.

Photo: M. H. W. Ritchie

Waller with the generator at Camp A1.

mid-June. The uniformity of the snow cover is believed to be due to blowing of the snow, which continued at intervals during our stay. From mid-June until early August, apart from one blizzard, steady melting occurred. The meltwater trickled down, part of it froze on to the old impervious ice surface and the rest became slush or flowed laterally into hollows to form lakes and into old river channels from which the slush suddenly discharged in great torrents to the edge. This made travelling and camp sites wet and adventuresome at increasing altitudes during the summer.

Above an altitude of about 760 metres several centimetres of newly-formed ice or very coarse crystalline snow remained, when persistent snow fell again during August. It is not known whether this is a regular accumulation or due to the poor summer, but comparison of the organic material from the older ice with that from the air may give some clues. This form of ice accumulation, however, is likely to have been regular at an earlier stage. Below about 760 metres old ice melting occurred and resulted in a maximum loss of about 2 metres at the apparent edge. In places new moraines to this height were formed out of debris from the shear planes.

The ice crystals both on the ice cap and on the mountain glaciers varied commonly from about 0.5 to 2.0 centimetres in size, and no significant change in size was noted near the surface at different altitudes.

The ice cap temperature 30 centimetres below the ice surface was about -13°C late in May and it increased almost to freezing point in early August. The ice temperature at a depth of about 9 to 10 metres remained constant at about -10.7°C, a reasonable value in relation to the mean annual air temperature. Few open crevasses were seen either on the ice cap or on the mountain glaciers. As soon as the meltwater started to flow, any crevasses filled and became frozen up by long hexagonal crystals growing outwards from the cold walls. Many such frozen crevasses were seen.

Movement of the ice near the edge of the ice cap, both adjacent to moraines and above a cliff about 30 metres high bordering Generator Lake, was small.

Meteorology. *By S. Orvig*

The ice cap meteorological station was established on May 27, and from June 1 to August 26 the following observations were made every 2 hours, from 0800 to 2200 daily: pressure (mercury barometer); temperature and humidity at 2 feet and at 23 feet above the surface; temperature at 12 feet; wind speed and direction at 7 and at 23 feet; also cloud, fog, visibility, and ceiling. At 0800, 1400, and 2000 hours maximum and minimum temperature and precipitation were measured. Sunshine was recorded by a Campbell-Stokes recorder, and barograph and thermograph records were kept for the 87 days with a few short interruptions caused by drifting snow.

Reports from Arctic Bay and Pond Inlet in northern Baffin Island seem to indicate an unusually bad summer this year. The nearest weather-reporting station was Clyde, some 100 miles northeast of the ice cap station. There the precipitation in June, July, and August of this year was above normal for the period 1942-7: 1.04 inches higher in June, 0.35 inches in July, and 0.73 inches in August. The altitude of the ice cap station was close to 2840 feet (870m.), which is approximately the normal height of the 900-millibar level. A comparison of temperatures and humidities at this level recorded on the twice daily radiosonde ascents at Clyde in the summers of 1949 and 1950 shows that all three months were slightly colder this year, and the humidity was markedly higher. It seems, therefore, that the humidity in the area was well above normal, but the temperatures probably not far from normal, though on the ice cap possibly a little lower than usual.

The most striking thing on the ice cap was the short "summer". Only 35 days had mean temperatures above freezing, the first being June 23, and the last August 10. Also unexpected was the heavy precipitation: 2.3 inches of rain and 49.9 inches of snow in 87 days. In spite of this, the 42 inches of snow found at the camp-site on arrival disappeared, and the ice surface was bare for four days in the beginning of August. On departure there was 14 inches of new snow, of greater density than the winter snow found in May.

The temperature and humidity measurements at the 2-, 7-, and 23-foot levels showed an almost permanent gradient, the air at 23 feet being warmer and drier than the surface layer, except in foggy weather.

Ablation of the snow in the first half of the summer was mainly caused by radiation, in spite of the low surface temperatures. June had the maximum sunshine, 184 hours, not counting the night-sunshine from 2015 to 0345 hours. Convection played a greater part later in the season. The evaporation was greatest early in the season, when the water-vapour pressure decreased most sharply with height. The amount of fog increased considerably in August, when some, or continuous, fog was recorded on 22 days out of 26. August had only 54 hours of sunshine. It is probable that the very short period when the ice was snow-free is unusual. The results of this summer's ablation studies should not be considered normal, other summers will almost certainly be more favourable for ablation of the ice surface.

Climate. *By Margaret R. Montgomery*

Camp B lay at the head of Clyde Inlet and about 40 to 45 miles east of the ice cap meteorological station. Apart from three brief interruptions during June weather observations were taken daily from May 25 to August 31, the following elements being recorded: pressure, by barograph

trace; temperature, both maximum and minimum, dry and wet bulb, and thermograph trace; precipitation, the number of occurrences only as there were no adequate facilities for measuring amounts, although some approximate estimates were made during the "heavier" rains in August with instruments improvised from general camp equipment; cloudiness, the percentage cover and the height, judged by eye estimate; and wind, both direction and strength, the latter was measured by anemometer until mid-July when the instrument was broken, after that estimates were made according to the Beaufort scale—this presented certain difficulties in a treeless, uninhabited land where such limitations as "whole trees in motion: whistling heard in telegraph wire: umbrellas used with difficulty" hardly seemed to apply.

It might have been expected that weather conditions at Camp B would be intermediate between those of the coast and those prevailing in the low, rolling interior. Comparison with reports from camps on neighbouring fiords, however, suggests that conditions at Camp B were decidedly more favourable than at the heads of the more exposed fiords and the station appears to represent a climatic "soft spot" reminiscent of similar protected areas in rift valleys and fiords along the Labrador.

Although still within the western fringe of the mountain zone of the east Baffin coast, Camp B, situated in an area surrounded by mountains 2000 to 3000 feet high, had a sufficiently low elevation (approximately 85 feet above sea level) to assure it considerable protection from much of the adverse weather experienced inland. At the same time, 12 to 15 miles to the east, in the vicinity of the great *S* bend of Clyde Inlet, the mountain barrier with peaks between 3000 and 5000 feet presented a formidable obstacle to surface winds and effectively broke much of the severity of weather travelling inland from the coast. This was particularly well illustrated in the latter part of August when the heavy, low cloud which blanketed the coast for several days was stopped abruptly by the mountain barrier, thus permitting the Camp B area to enjoy brilliant sunshine broken only by scattered patches of cumulus.

Camp B records showed a total of 67 days in June, July, and August with minimum temperatures above 32°F. The only continuous frost-free period was from July 15 to August 20 inclusive, and the snow which fell during the last days of this period did not continue to lie on the ground at station level although it persisted for several days above the 1000-foot level on the surrounding mountains. All "summer" months, particularly June, showed temperatures below 32°F, although with the two exceptions of July 14 (31°.5F) and August 20 (31°.7F) these sub-freezing temperatures occurred only in the first five days of July and last two of August. Only on eight days did the minimum temperature remain above 43°F. Mean maximum temperatures registered were about

40°F in June, rose to about 52°F in July, and fell to approximately 48°F in August. The highest temperature recorded for the season was 71°F on July 29.

Since the 1950 summer was a particularly unfavourable one according to the records of the regularly established Baffin Island stations, it seems probable that, in a "normal" year higher mean temperatures and a frost-free period of about six weeks duration might occur at Camp B.

In all months the mean and maximum temperatures, as well as the temperature range, were higher at Camp B than at Clyde while the pressure readings were almost invariably lower.

Throughout the summer, precipitation was extremely light, and only rarely interrupted field work. The period of heaviest rain occurred in the second and third weeks of August when, on three occasions, an estimated 0.12 inches of rain fell during a period of 6 to 9 hours. Under these conditions, moisture for plant growth was supplied, not by summer rains, but by the melting of winter snows. During the first warm spell at the end of June the suddenly-released meltwater flooded the river beds, making a number of them impassable for some time and, in areas of poorly defined drainage, covered large sections of the plains and valley with pools of water, many of which never dried up completely.

Surface winds in the area were deflected by the mountains and the channelling effect of Clyde Inlet was clearly evident in the predominance of winds with a strong easterly component, about 60 per cent of the total observations. East winds were most frequent in the warmest period when the contrast between the warm, dry air at the head of the inlet and the cooler air of the coast was most marked. Wind velocities ranged all the way from "calm" on a few rare days in July and August to gusts exceeding 50 m.p.h. when deep depressions influenced the area and intensified the channelling effect of the inlet.

As mentioned earlier, comparison with locations at the heads of neighbouring fiords less protected from the direct influence of winds off Baffin Bay, suggests that Camp B enjoyed a more favourable climate than was typical of the area as a whole. The aridity, the high daytime temperatures, and the diurnal range of temperature even during the period of continuous daylight, all stress its continental character—a character which would doubtless be even more apparent during a favourable summer.

Ecological Study of the Vegetation. *By Pierre Dansereau*

The biologists spent most of the time at the head of Clyde Inlet where there is a great variety of topography and altitude. Trips were made to the coast, to various points on other fiords, to the edge of the ice cap, and to Foxe Basin. On the return voyage aboard the *C. D. Howe* Pond Inlet, Arctic Bay, Dundas Harbour, and Frobisher Bay were visited. Observations, measurements, and collections were made at all these places.

However, most of the detailed work was done at the head of Clyde Inlet, where a careful ecological survey was carried out and a record was obtained of biological events throughout the growing season. The following outline refers to work in this area.

Vascular plants collected number a little over one hundred species. The great majority are widespread arctic types. A few are indicators

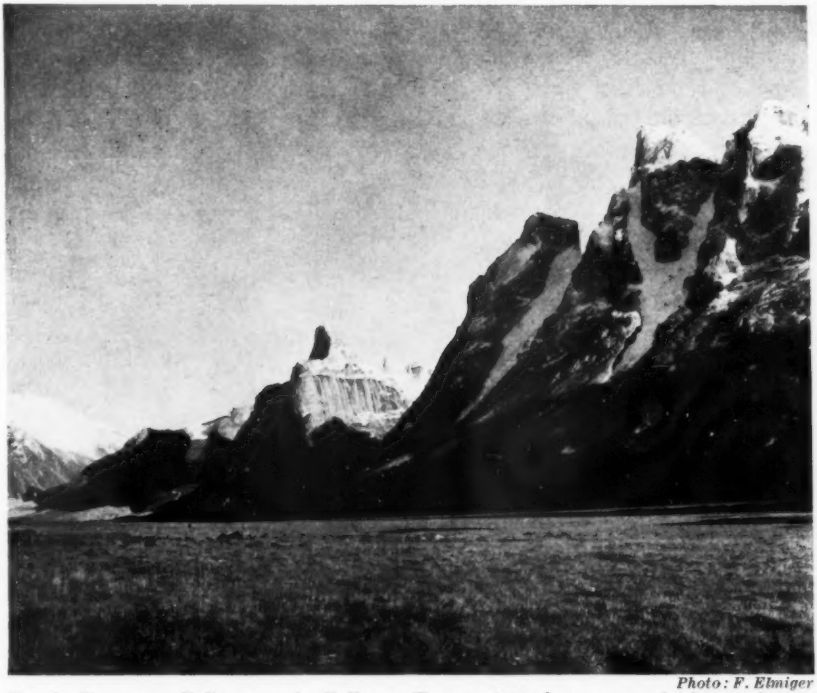


Photo: F. Elmiger

Revoir Pass near Eglinton end. Eglinton Tower, 4100 feet, centre background, was climbed for the second time on 27 August 1950; first ascent T. G. Longstaff 21 August 1934.

of a southern penetration or of locally warmer conditions: *Salix cordifolia* and *Dryopteris fragrans*. Some appear to be relics of older or possibly primitive types: *Crepis nana* and *Erigeron compositus*. The discovery of the latter is of especial significance as it has not previously been recorded in eastern North America between Ellesmere Island and the Gaspé Peninsula.

A considerable collection of lichens and mosses was assembled. The latter will be identified by W. C. Steere (Stanford University). The lichens were collected and studied by Mason Hale.

Special attention was given to the ecological conditions in which each species was found and to the morphological variation involved. It is a remarkable feature, which has not been sufficiently emphasized, that many arctic species have a very broad range of habitat. Most of these,

such as *Saxifraga oppositifolia* and *Dryas integrifolia* also enjoy a wide geographical range, and play an important ecological role in more than one community. On the other hand, species that appear to be confined to a single habitat also have a discontinuous, if broad, distribution, such as *Crepis nana*, *Dryopteris fragrans*, and *Erigeron compositus*. Many species are strikingly variable in leaf-shape, habit, and other visible characteristics. This would seem to imply a very mixed heredity, a condition of great importance to the survival of plants in a rigorous and probably unstable environment. In some cases, such as *Potentilla* and *Salix*, hybridization is involved, and there is more than a suggestion of local contamination of one species by another.

A record of the periodic behaviour (budding, leafing, flowering, fruiting, shedding) was taken of all the dominant species, and together with microclimatic measurements should make it possible to delimit the seasons.

Observations in this area will have some bearing on the general concept of plant association. It can be suggested that the replacement of one plant community by another, invading, plant community is slowed down and tends to attenuate the sharp differences in botanical composition of each unit and to emphasize transition stages. A rather close resemblance was found between the vegetation of high altitudes, late snowdrifts, and glacier edges. Although the order of succession of these associations can be estimated, the absolute time scale is difficult to establish.

It was found that the microrelief often favoured the formation of microhabitats within a community which is of great significance as the role of the latter in soil building was considerable. They also produced layering of vegetation and a rather complex interaction of species usually involving flowering plants, mosses, and lichens.

Quantitative floristic surveys were made in small homogeneous areas in order to sample all the vegetation types present. An attempt was also made to find the relationship of floristic units to landforms, soils, and microclimates. Many pictures and diagrams were drawn of selected stations in order to explore the entire range of topographic and edaphic conditions, such as the relation of vegetation to various patterned soils. With the collaboration of Miss Margaret Montgomery, temperature measurements were taken at regular intervals at different depths in the soils of these stations. These measurements show a characteristic pattern in each group and record the recession of the frost line and the retention of heat in the various soil layers.

Lichens. *By M. E. Hale*

The writer took part in the expedition as lichenologist and assistant to Dr. Dansereau. This is the first time that a biologist with experience in lichens has made field studies of the Eastern Arctic lichen flora and

has remained at the same station for a whole summer. Most of the time was spent at Camp B, at the head of Clyde Inlet, where large collections were made and the lichen communities studied. About 200 species were found, more than was previously known for the whole of Baffin Island. Brief visits were made to the ice cap, Clyde settlement, Frobisher Bay, Padloping Island and the Cape Searle bird cliffs, Pond Inlet, and Arctic Bay, so that it was possible to compare the lichens of these areas with those of Clyde Inlet.

Determinations of the large collections are still in progress, but a few of the more interesting discoveries of macrolichens thus far are as follows:

New to the Canadian Eastern Arctic–*Nephroma expallidum*, *Peltigera polydactyla*, *Solorina octospora*, and *Xanthoria fallax*.

New to Baffin Island–*Parmelia infumata*, *Peltigera canina* var. *rufescens*, *P. malacea*, *Solorina bispora*, and *Umbilicaria deusta*.

Significant range extensions–*Nephroma arcticum* (Lake Gillian), *Cetraria Tilesii*, which was found repeatedly on limestone throughout the area, *Cladonia alpestris* (to Pond Inlet), *Parmelia incurva*, common to all stations, and *Peltigera venosa* (to Pond Inlet).

Names on the Map

The following new names have been adopted by the Canadian Board on Geographical Names:

Ayr Lake	To perpetuate the name North Ayr given to this region by Ross.
Barnes Ice Cap	After the late Howard T. Barnes, Professor of Physics at McGill University, who carried out much research on ice.
Clyde River	River running into Clyde Inlet.
Cormack Arm	After John Cormack, formerly Hudson's Bay Company's post manager at Clyde.
Flyway Lake	From the migrating route of king eider ducks.
Gee Lake	A geological campsite of the expedition.
Generator Lake	The expedition generator was set up near this lake.
Inugsuin Fiord	After the Eskimo name as reported by Boas.
Revoir Pass	At one period Dr. and Mme. Dansereau were at opposite ends of this pass.
Sam Ford Fiord	After Sam Ford who was drowned in a helicopter accident off the Koksoak River and had at one time been H.B.C. post manager at Clyde.
Sam Ford River	River draining into Sam Ford Fiord.
Swiss Bay	Camp M1 here was the headquarters of the Swiss group.
Walker Arm	After Captain J. B. Walker, a whaling captain, who made an early map of this district.

Photo: R.C.A.F.

Photographic Lancaster on an arctic flight.

PHOTOGRAPHIC OPERATIONS OF THE ROYAL CANADIAN AIR FORCE

By* Wing Commander R. I. Thomas, R.C.A.F.

A SERIOUS program of mapping Canada was begun in 1902 but it soon became apparent that the accepted ground methods were too slow to keep pace with the development of the country. After the First World War the Department of the Interior, faced with the apparently hopeless task of mapping Canada within the lifetime of that generation, requested that the Air Board should cooperate in carrying out aerial mapping.

The first attempts were made in 1921 and although the results were limited they were sufficiently successful to reveal the possibilities of aerial photography. The role of the operator of the aircraft was handed to the Royal Canadian Air Force when it was formed in 1924, and the development of equipment for the work was the responsibility of the National Research Council. Through the years the closest possible cooperation has evolved between three widely separated branches of government: Department of Mines and Technical Surveys, the National Research

*Officer Commanding 22 Photo Wing, R.C.A.F.

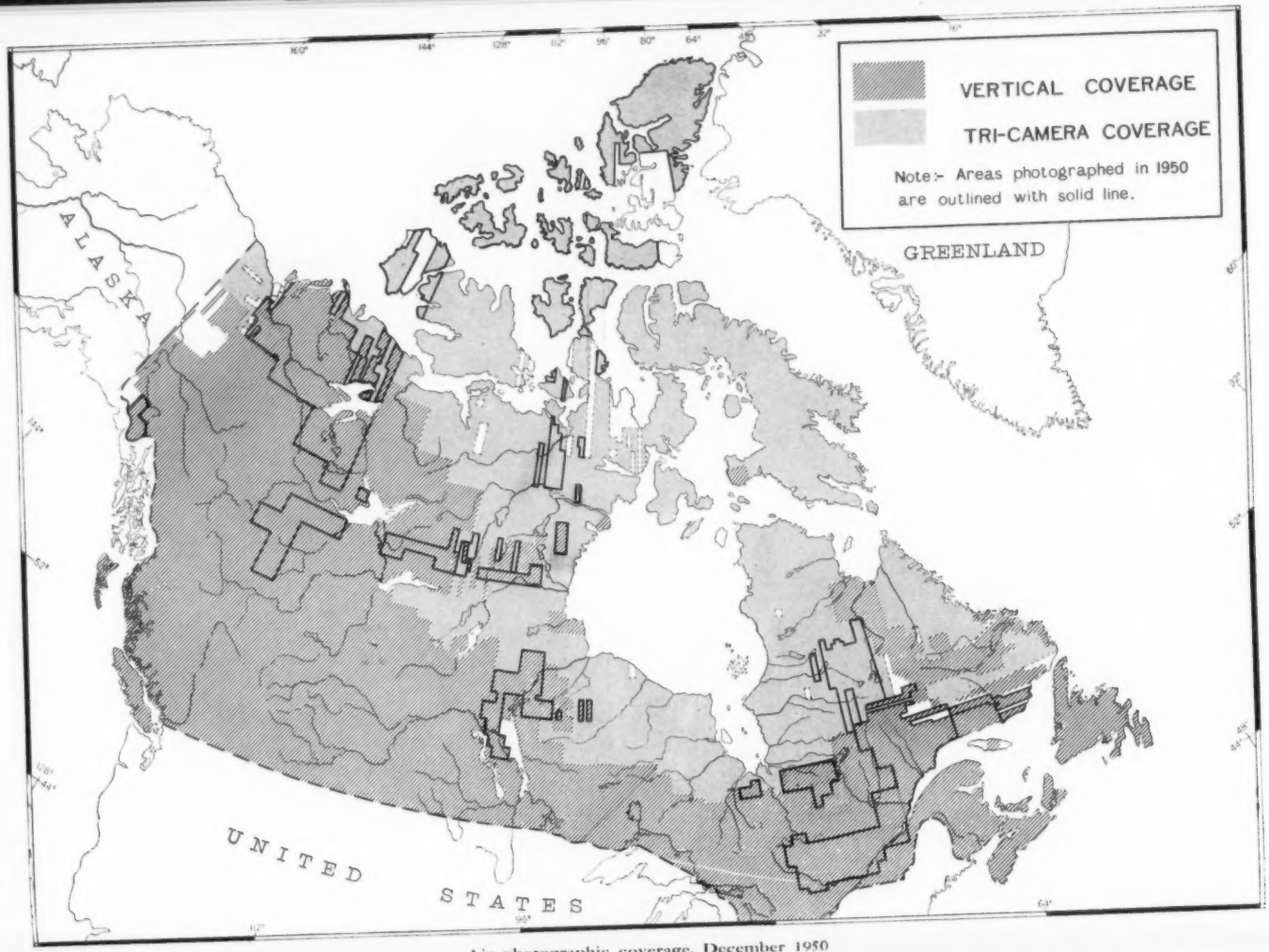
Council, and the Royal Canadian Air Force, representing the photogrammetrist, the research worker, and the air operator. This close liaison has been an important factor in the growth and efficiency of Canada's photographic survey program. During the past twenty-nine years Canada's program of aerial photography has increased from a yearly coverage of 280 square miles in 1921 to the all-time record of 911,500 square miles in 1948. An additional 1,741,500 square miles of coverage were added in 1949 and 1950 to bring the total number of negatives held in the storage vaults at Ottawa to 3,750,000.

Although aerial survey formed quite a large part of the overall R.C.A.F. commitment during the period 1924-39, progress was slow. The type of aircraft available and the angle of the lens in use in aerial cameras kept the coverage at a relatively low figure. The largest coverage in any one year was approximately 109,900 square miles, and the total by 1939 was only 868,600 square miles.

With the outbreak of the Second World War in 1939, the squadrons employed in photo survey operations were converted to bomber reconnaissance work and survey operations came to a standstill. However, in 1944 photo operations were again requested of the R.C.A.F. and as a result No. 13 Survey Squadron (later renamed 413 Survey Transportation Squadron in 1947) was formed at Rockcliffe (Ottawa) to undertake limited commitments. By 1945 the urgency for maps along the proposed Alcan Highway and in the Mackenzie Basin was so great that two squadrons were committed to photo survey and since then the effort of the R.C.A.F. has been increased to three squadrons and has mainly been concentrated in the Canadian north. In 1949 and 1950 it involved some 550 personnel and 33 aircraft in the field with several hundred personnel at Rockcliffe.

The organization set up to handle the tremendous commitments of photo survey in 1949 and 1950 consisted of 22 Photo Wing Headquarters, which coordinates all the work; three squadrons, 408 and 414 Photo Squadrons and 413 Survey Transportation Squadron; and No. 1 Photo Establishment, which is responsible for processing the films. Under the latter unit, but operating as a separate entity, is No. 1 School of Photography where photo training of the R.C.A.F. is undertaken. 22 Photo Wing Headquarters at Rockcliffe effects control in the field through a network of nine signals units linking all advanced bases direct with Rockcliffe. This efficient signals link has proved a vital factor in the achievement of large coverage during the past three years.

Today two main types of photographic survey are undertaken: vertical and tri-camera. The former employs a single camera and is used for detailed mapping. In this photography lines are flown at intervals of three miles or less in most areas, to give 60 per cent forward and



Air photographic coverage, December 1950

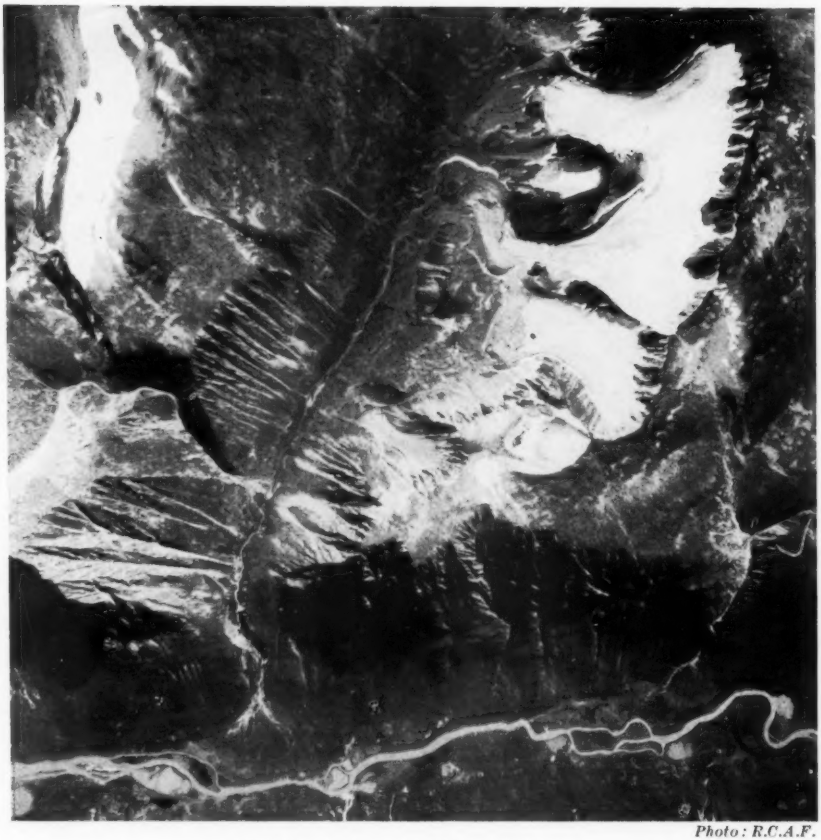
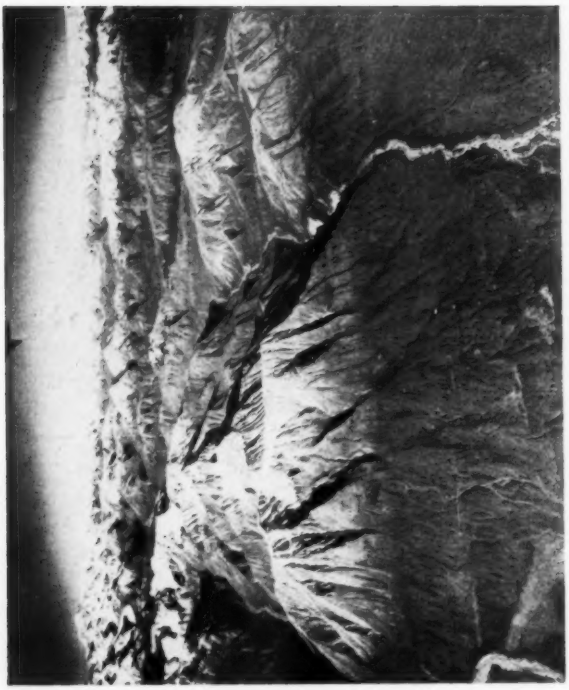


Photo: R.C.A.F.

Vertical photograph, Watson Lake area.

30 per cent lateral overlap. The resulting photographs can be used to produce contour maps of great accuracy and are normally used for maps of 4 miles to 1 inch or larger scale. Tri-camera photography, in which three cameras in a single mount work simultaneously from the aircraft, produces a fan of three photographs. This method sacrifices accuracy for coverage but is approximately six times as rapid as vertical photography. With the precise calibration now used it is possible to produce accurate 8 mile to 1 inch maps from tri-camera photographs and, where there is very little relief in the terrain, 4 mile to 1 inch maps of reasonable accuracy. Because of the large areas that can be covered in a comparatively short time this method has proved to be of great value in the initial mapping of the north where the season is short and detailed maps are lacking for the more precise navigation required to produce good vertical coverage. All the National Topographic Series maps of northern Canada are being produced from tri-camera photographs.

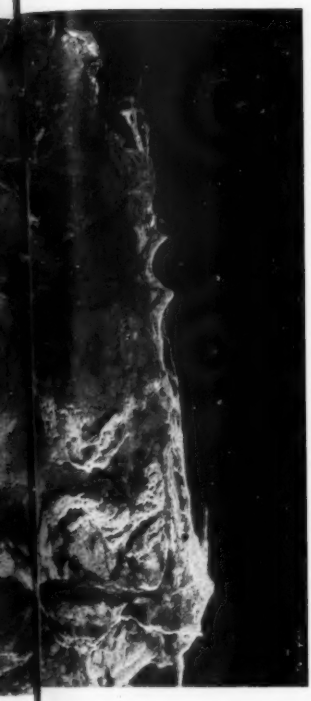
Air photographic coverage, December 1950



Tri-camera fan covering approximately 8000 square miles, Kluane Lake area. The Alaska Highway in the

When the aerial survey program was initiated, only vertical photography was used. However, the slow speed and low ceiling of the available aircraft and the relatively narrow angle of the camera lens soon led to the adoption of the speedier oblique photography. This type of photography was produced by one camera taking a fan of three exposures as close together as possible covering a field of 180° in front of the aircraft. The camera operator was in the nose of the aircraft, a Vedette flying boat. The camera was mounted on a scarf ring which could be adjusted to compensate for drift and the operator was responsible for getting the right angle of depression on each exposure. The plotting of such photography was difficult and the results not too accurate, but many maps still in use were produced from such work.

The next step was to use three cameras in a single mount facing to the rear of the aircraft. The cameras were calibrated with fair precision to the mounts and the results were considerably more accurate than those obtained with the oblique method. Further development led to the present day tri-camera set-up. This installation is a development, much refined, of the American tri-metrogon principle, which in turn goes back to the old oblique mounts. The side cameras are set at 90° to the centre line of the aircraft and depressed 30° while the centre camera is set vertical.



Photos: R.C.A.F.

...n in the centre photograph: note the overlap has been trimmed from the two side photographs.

This produces a fan covering from horizon to horizon through the vertical which is plotted in strips 16 miles wide, with the accuracy of vertical photography in the middle and a falling off of accuracy for eight miles to each side. Fairchild F224 cameras with 6-inch f.6.3 Bausch and Lomb Metrogon lenses are used for tri-camera photography. They have a 250-exposure magazine for a 9 inch by 9 inch negative. The suction back is used to hold the film and the fiducial marks are affixed to the body of the camera. These cameras give excellent definition even from 20,000 feet, the normal operating height, and they have been relatively trouble-free since brought up to R.C.A.F. specifications.

Vertical photography is carried out with Williamson Ordnance Survey cameras using 6-inch f.5.5 Ross Wide-angle Survey lenses. These cameras have a 500-exposure magazine, also for a 9 inch by 9 inch negative. The pressure plate method of holding the film is used and the fiducial marks are etched on the focal plane glass. The definition is excellent and the performance very good since R.C.A.F. modifications have been installed. Vertical coverage is also from 20,000 feet.

Since 1945 the major part of the photographic survey program has been carried out in the north. In 1948, when 911,500 square miles of northern Canada were photographed, photographic survey operations

were carried to the Arctic Islands for the first time. In that year all of Baffin Island was photographed in addition to large areas of the Labrador, Ungava, the Northwest Territories, and the Yukon. In 1949 operations were continued in the Arctic Islands. Photographs were taken of Victoria Island, King William Island, and parts of Somerset Island, Banks Island, Boothia Peninsula, further areas of the Yukon and Northwest Territories, the Labrador, Ungava, and northern British Columbia. In 1950 operations were pushed even farther north. Further coverage was obtained on Victoria and Banks islands and most of the islands north of Lancaster Sound were photographed.

Tri-camera photography is undertaken exclusively by 408 Squadron. This squadron consists of eight long-range Lancaster X aircraft, equipped with three Fairchild F224 cameras precision-mounted in a single mount. The cameras are tied-in to each other to within 10 seconds of arc and each camera is jig-drilled to be interchangeable without disturbing the calibration. In addition, these aircraft carry Williamson Ordnance Survey cameras for vertical coverage.

Three of 408 Squadron's aircraft are equipped with special instruments and wiring developed by the National Research Council for Shoran-controlled photography. Shoran is a recent development in the survey field and has been proved in operation in 1950. It involves using airborne radar equipment in conjunction with ground radar beacons spaced several hundred miles apart, and allows aerial photographs of the area concerned to be positioned accurately.

In addition to controlling photography accurately by Shoran, it is hoped that this method of control can be used to establish accurate fixes in the north. To do this the photo procedure is reversed. In photo, two ground stations at known positions are used to locate the position of the aircraft, whereas in applying Shoran to survey the aircraft flies at a known height above sea level and measures the slant distance between it and two ground stations. From the results the distance between the two ground stations is calculated. This method has been used in the United States successfully but not to the degree being attempted in Canada. In 1949 measurement was begun of a large network of Shoran stations stretching from the Winnipeg area to Fort Vermilion in Alberta, a distance of approximately 1200 miles. This program was completed in 1950 and the soundness of the procedure developed was definitely proved. Accuracy in the order of 1/58,000 has been achieved. Shoran measurement is believed by R.C.A.F. and Department of Mines and Technical Surveys authorities to be more accurate than the present system of setting up astronomical fixes.

Vertical photography is primarily allotted to 414 Squadron which is entirely committed to this work, although aircraft of 408 Squadron may

Photo: R.C.A.F.

Camera operator at the controls of a tri-camera mount in a Lancaster aircraft.

Photo: R.C.A.F.

Camera operator and control panel for Williamson Ordnance Survey camera as installed in a photographic Dakota aircraft; camera in foreground.

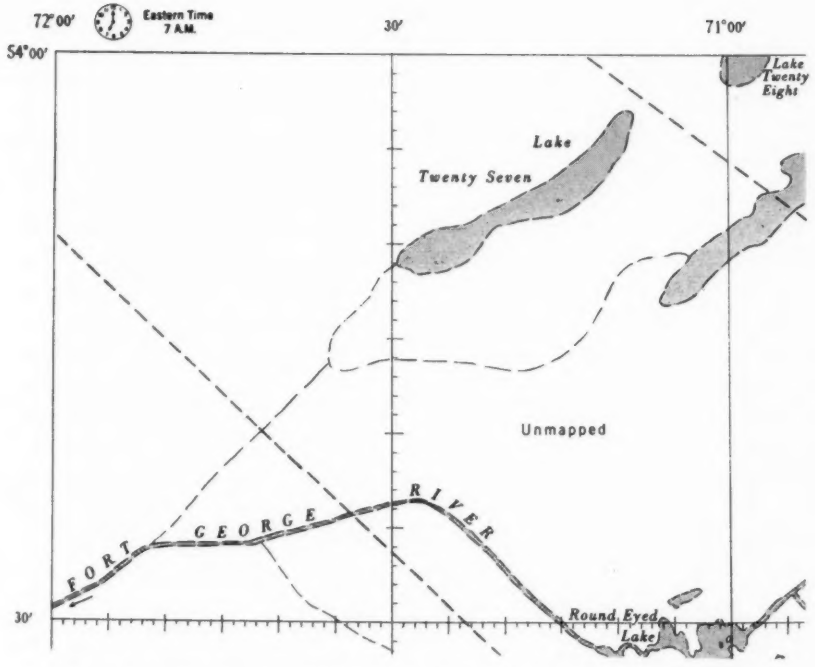
take vertical photographs when tri-camera areas are not available. 414 Squadron was formed in 1945 to meet the requirements of the defence mapping program in the Yukon and Northwest Territories. It is equipped with 14 Dakota Mark IV aircraft specially modified with long-range cabin tanks and a cabin well to accommodate a Williamson Ordnance Survey camera. The cameras are electrically heated and thermostatically controlled to within $\pm 4^{\circ}$C.

The supply problem for the two photo squadrons had grown to such large proportions by 1949 that a survey transportation squadron was organized. The original postwar photo squadron, 413 Squadron, was chosen for this work. It is equipped with 4 Dakota, 6 Canso, and 5 Norseman aircraft. In addition it undertakes flying boat transportation for other government departments.

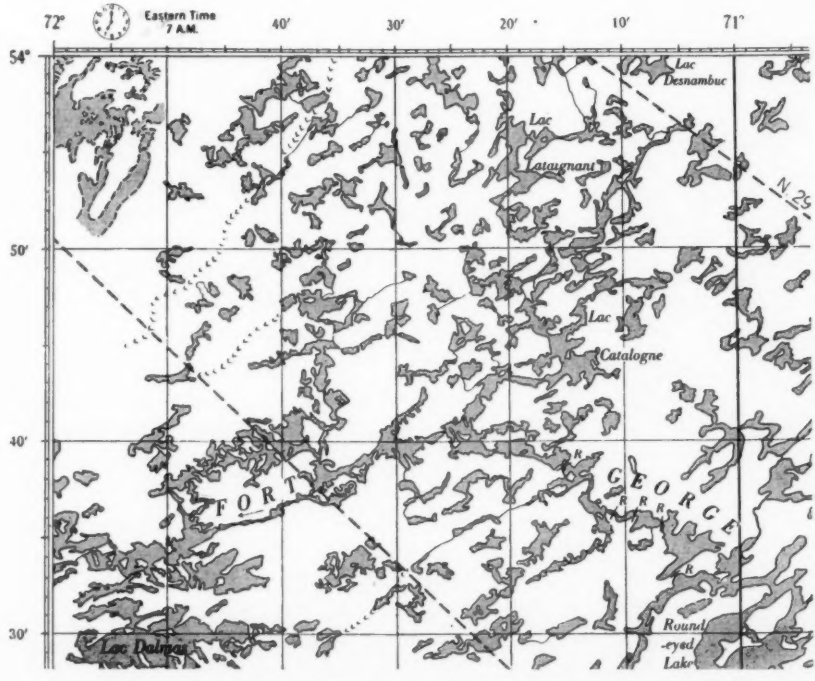
The commitments for each season of aerial photography are decided by the Interdepartmental Committee on Air Surveys. A sub-committee, with a permanent secretary from the Department of Mines and Technical Surveys and representatives from the government departments using the R.C.A.F. aerial photographs, considers requests for photography and decides on the specific areas to be covered by the R.C.A.F. and by civilian companies. Members of the Air Transport Command and of the photographic squadrons also attend the meetings of the sub-committee to advise on the possibility of carrying out the various requests. Thus it is known by both the R.C.A.F. and the requesting agency that the commitments are practicable.

Whenever possible tri-camera coverage is obtained before vertical photography is attempted. Although this involves an additional year's delay in producing 4 mile to 1 inch maps, it means that much improved maps become available earlier for use by commercial firms wishing to explore what may be almost virgin territory and the procedure has proved to be beneficial to all concerned. The areas allotted to commercial companies are normally adjacent to rail or sea transportation and are of a much smaller size than those assigned to the R.C.A.F.

As soon as the specific areas to be photographed have been determined, plans can be made. Coverage is assigned to the two squadrons, bases are decided upon, and the flight line maps are drawn up. The R.C.A.F. always requests a considerable area over and above the expected coverage, thus adding greatly to the flexibility of the program and to the coverage that may be possible in one season. For example, in 1949, when operations were being carried out in the Yukon, flight line maps were prepared for approximately 100,300 square miles more than the original vertical commitment. The weather turned out to be particularly good that season and in three weeks practically the entire commitment, including the additional area, was covered. Had the extra flight line maps not been



Part of the Nichicun (23 S.W.) 8 mile to 1 inch sheet before photography.



Part of the Nichicun (23 S.W.) 8 mile to 1 inch sheet after photography.

available, the aircraft would have been on the ground for approximately one week of good weather because of lack of areas to photograph.

The timing of the detachments into various areas is a major factor in planning. Because of the short season in the north it is now left to the R.C.A.F. to decide when operations in a particular area are carried on. In the past a great deal of good weather was lost by holding detachments in southern areas until a high priority commitment was completed. Now detachments work in the south only until photography is possible in the north. The detachments go into the field any time after the snow has gone from southern areas and ice on lakes has started to break away from the shores. This usually means that the first detachment leaves Rockcliffe between April 25 and May 1. A detachment generally makes four moves in a season: the first from Rockcliffe to a southern base, then to the northern base when the area opens, and back to a southern base before returning to Rockcliffe. The season is normally over by the middle of October but special commitments are sometimes received which drag the season on to December.

The preparation for any aircraft operation in the north must begin approximately 18 months ahead of time. It is necessary to lay in gas and oil one year ahead to have it available to start photography when the season opens, as snow is gone from the land and photography is possible before navigation starts. Once a cache has been assured at a base the detailed planning gets under way in the fall and winter. Rations, accommodation, and spares are laid on, crews trained, and aircraft serviced for the photo season.

The extensive manner in which photo operations are undertaken today calls for the greatest amount of flexibility within the organization of the squadrons. This is attained by sub-dividing the squadron into smaller formations or detachments. Each detachment is a completely self-sufficient unit and consists of ground crew and air crew. The ground crew includes aero engine, air frame, radio, electrical, instrument and safety equipment technicians, in addition to cooks and mess orderlies. The air crew includes pilots, navigators, and radio officers as well as the camera operators. Each detachment must take with it spares for the aircraft, ground handling and servicing equipment, rations, and personal clothing. This latter is quite an item alone since the weather at such places as Coral Harbour or Norman Wells can be very cold in early May or June and in late August. The weight of equipment for a Dakota detachment of three aircraft and forty-five personnel is approximately 75,000 lbs. which gives some idea of the effort involved.

Many of the earlier problems encountered by the photo crews have now been eliminated or solved through the use of long-range aircraft and the availability of northern bases. The problem that still retains its formidable stature and determines the area that can be covered in a season

is the weather. The retreating winter season is followed closely northward, and the work is done on the heels of the melting snow and ice. In some areas convection cloud forms as the land warms, and it is not unusual to find only a few days during the entire season suitable for photo operations. To obtain coverage of these areas the R.C.A.F. must be on the spot, ready to fly 10 to 15 hours a day, while conditions remain good, a feat made possible by nearly continuous daylight during the summer months.

To reduce the flying required to check weather and to be able to concentrate available aircraft on an area where weather conditions are suitable for photography, a system of control has been worked out with the Meteorological Division. Certain centres are chosen to supply meteorological information to the survey squadrons and, where possible, the Department of Transport assigns an extra forecaster at these centres who passes special forecasts to the detachments. The aircraft may then be moved from one base to another to take maximum advantage of the weather. In some cases quite extensive communications channels have had to be set up. For instance in 1948, when operations were being carried out in Baffin Island and northern Quebec, meteorological data from the northwestern Arctic was picked up by R.C.A.F. field units from the Department of Transport at Coral Harbour and then passed to Goose Bay through the R.C.A.F. unit at Fort Chimo. Had normal Department of Transport channels been used the data would have had to be sent to Edmonton and Winnipeg for re-transmission to Goose Bay and the delay caused would have been too great for the data to be of use in the survey operations.

The normal day on a photo detachment starts at about 3 a.m. when the duty crew checks the final weather forecast and prepares to make a flight to check actual weather. The first aircraft are usually off by 5 a.m. and if clear conditions are found the other aircraft are called by radio and take to the air. Where areas are widely dispersed two aircraft will go out from the same base on weather checks if forecasts are at all favourable.

On the average flight the aircraft is climbed gradually to approximately 10,000 feet and the flight in search of clear areas continued at that altitude. In this way a great deal of oxygen is conserved since many flights prove fruitless. This is important since it requires three high pressure bottles of oxygen to replenish an aircraft's system after approximately 10 hours of use and each of these bottles weighs 155 lbs. Wastefulness would soon cause a serious problem of resupply.

When a clear area is sighted the aircraft climbs to 20,000 feet and the crew makes final preparations for the photo line flying. Cameras are given a short test run, the solar navigator (an adaptation of an astro compass) is set up, and the aircraft is trimmed carefully for straight and

level flight. The trips to the operational area are done on Dead Reckoning navigation since maps are very inaccurate. A three course wind[1] is usually found before starting down the first line to give the navigator a course to fly and to help him in checking the end of a line.

Once the area is reached the navigator becomes virtually the captain of the aircraft and directs the pilot to the beginning of the first line to be attempted. Turn onto line is done about 15 to 20 miles back from the start of the line shown on the map. The drift is checked carefully and

Photo: R.C.A.F.

Photo survey Norseman refuelling from drums at Sawmill Bay.

the solar navigator started. Meanwhile the camera operator checks the interval and drift on his view finder and levels the camera. As the start of the line approaches the navigator gives the order to start the camera.

On the line the navigator is very busy checking drift every ten minutes at least and making new settings on the solar navigator. In between times he is trying to pick up pin points and also sketch in on his flight line map any details which might help him on his next line. This latter takes a lot of experience and the degree to which a navigator can learn to sketch generally measures his success at flight line flying in the north where maps are most inaccurate.

The second pilot assists the navigator in map reading while the first pilot is occupied in maintaining the required heights within ±50 feet and

[1]Previous to flying photo lines determinations of the drift are made on three headings and with knowledge of the true air speed the wind velocity can then be calculated on a navigational computer.

holding course to within less than 1 degree. This calls for intense concentration and not all pilots can measure up to this exacting requirement. When flights last as long as 10 hours the two pilots and the navigator are very weary indeed by the time they reach base again. Even those crew members who are not engaged in such exacting tasks are tired out after 10 hours at 20,000 feet on oxygen.

One of the major problems in the north is maintaining direction. The best magnetic compass becomes erratic in higher latitudes and the

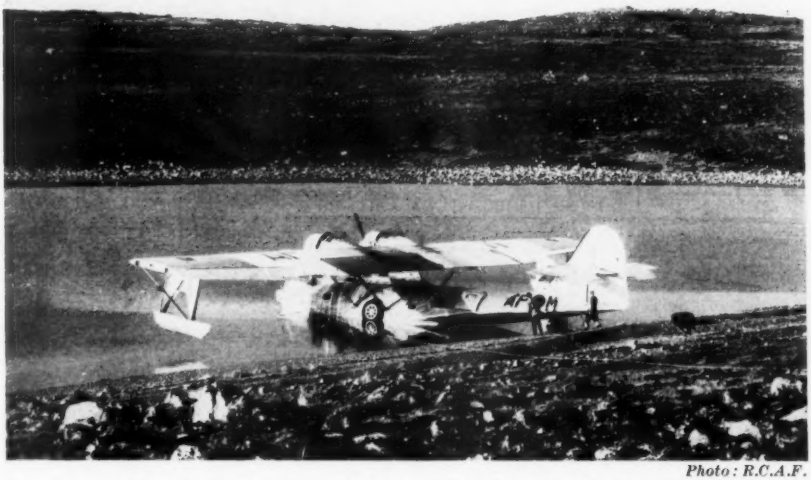


Photo: R.C.A.F.

Photo survey Canso being hauled up the beach at Ross Bay, Melville Peninsula, for replacement of damaged nose section and propellor.

vacuum driven gyros do not stand up very well. Even gyros corrected for the mean latitude of the operations may go unserviceable and precess excessively after a very short time. The solar navigator is used to direct the pilot for straight line flying, and the astro compass is used to supply settings for the gyro instruments.

Another major problem is servicing the aircraft in the more isolated bases. No hangars or other permanent facilities are available at such places as Norman Wells, Yellowknife, or Coral Harbour, and the work must be done in the open, in rain, snow, or sun as the case may be. Dust is another constant torment to the hard-worked ground crew. Refuelling has to be done from barrels and even with portable electric or gas operated pumps this is a long process. Often the caches are established some distance from the nearest taxi area and the barrels must be man-handled

to the vicinity of the aircraft. In spite of the limited facilities remarkable records of serviceability are achieved. One squadron maintained 100 per cent serviceability on twelve aircraft for approximately a month during which they flew 1700 hours and covered 120,000 square miles of vertical photography.

Film exposed in the field by the survey planes is shipped to No. 1 Photo Establishment at Rockcliffe for processing. Possessing one of the

Photo: R.C.A.F.

Laying down photographs to make a mosaic.

world's finest and most modern aerial photographic laboratories, this establishment plays a vital part in the overall photo survey program. The exposed rolls of film are sent in with a full report listing the area covered, weather conditions at the time of exposure, height and speed of aircraft, and other details. The film is put through continuous processing machines for development, and is turned out at the rate of 5 feet a minute. The negatives are then placed on annotating tables with glass tops lit from underneath. Here the film is given an initial check for accuracy and quality, and each negative is numbered to allow instant identification. Possible gaps in the area being covered, caused by camera failures or lack of forward overlap, are spotted at this stage. Highly skilled personnel are required, and the ability of the establishment personnel to analyse camera faults quickly from the negatives and pass the information to the

detachment in the field has been an important factor in reducing the amount of film wasted in recent years.

The negatives are then printed and laid out in a mosaic. The mosaic shows whether any lateral gaps exist as a result of errors in navigation. The lay down, as this mosaic is called, is photographed and, if there are gaps, the detachment which flew the lines is notified and prints of the lay down are sent out to be used in doing the refly. In the past only the latitude and longitude of each end of the gaps were sent to the detachment and with the inaccuracies of the existing maps it was not uncommon for two or three attempts to be made before complete coverage was obtained. The present method of checking and reflying gaps has proved most effective and has reduced flying time to a minimum.

All negatives taken for the government are stored at No. 1 Photo Establishment and are indexed at the National Air Photographic Library of the Department of Mines and Technical Surveys. The centralizing of all processing and storage of negatives has permitted rigid control of quality and has contributed materially to the success of Canada's aerial survey program.

The R.C.A.F. is not responsible for map making. The finished prints are turned over to the Department of Mines and Technical Surveys or the Army Survey Establishment which are responsible for the compilation of maps.

Canada's aerial survey program has not only made it possible to map vast areas of the country that were previously almost unknown, it has also revealed startling inaccuracies in existing maps. In 1934, for instance, it was discovered that on current maps Akimiski Island in James Bay was lying north-south instead of east-west, and in 1948 photo survey aircraft rediscovered two uncharted islands in Foxe Basin, with a total area of more than 5500 square miles. Although the government's survey program is primarily designed for the compilation and correction of maps, the air photographs serve many other purposes. They have proved to be useful in mineral exploration, water power development, forest and agricultural surveys, and town-planning investigations and are made available to both government agencies and commercial organizations.

As of December 1950 2,391,300 square miles vertical and 2,176,300 square miles tri-camera photo has been obtained by the R.C.A.F. There remains approximately 10 per cent of Canada which has not been photographed. That these figures add up to more than the accepted land mass of Canada is explained by the fact that vertical coverage duplicates the tri-camera and some areas are reflown at a different scale. Today tri-camera photography of the north is practically complete and future effort in this area will concentrate on vertical photography for detailed mapping and the completion of Shoran control.

OBSERVATIONS ON A CYCLIC DECLINE OF LEMMINGS (*LEMMUS*) ON THE ARCTIC COAST OF ALASKA DURING THE SPRING OF 1949

By **Robert Rausch***

THE importance to the biotic community of various species of lemmings in arctic and subarctic regions has long been recognized, but there is little known about the ecology of these mammals. During the spring of 1949 the writer had the good fortune to observe a cyclic decline in the population of the brown lemming on the Arctic Coast of Alaska. Observations were made during the peak density preceding this decline (Fig. 1),

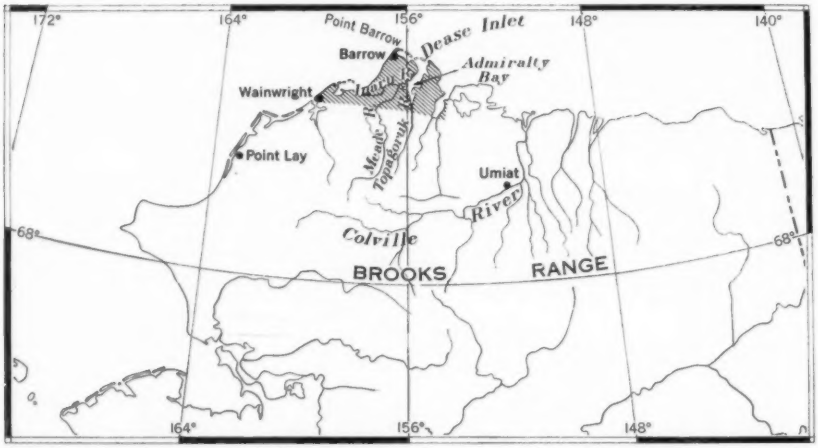


Fig. 1. The shaded area indicates the known extent of lemming density during the spring of 1949.

and were continued for more than a year subsequent to it. It is the purpose of this paper to present the results of these studies.

Two species of lemmings occur on the Arctic Slope of Alaska; they are the collared lemming, *Dicrostonyx groenlandicus rubricatus* (Richardson), and the brown lemming, *Lemmus trimucronatus alascensis* Merriam. While both of these were observed during the course of this study, only the brown lemming was present in great numbers. However, both species were affected by whatever factors were responsible for the mortality which caused a precipitous decline in lemming numbers.

The writer began observations on lemmings in the Point Barrow region on 22 March 1949, when an effort was made to secure some of the rodents for parasitological examination. Field observations made over this period are briefly presented here. This opportunity is taken to express appreciation to the Arctic Research Laboratory, Office of Naval Research, whose cooperation made this work possible.

*Parasitologist, Arctic Health Research Center, Anchorage, Alaska.

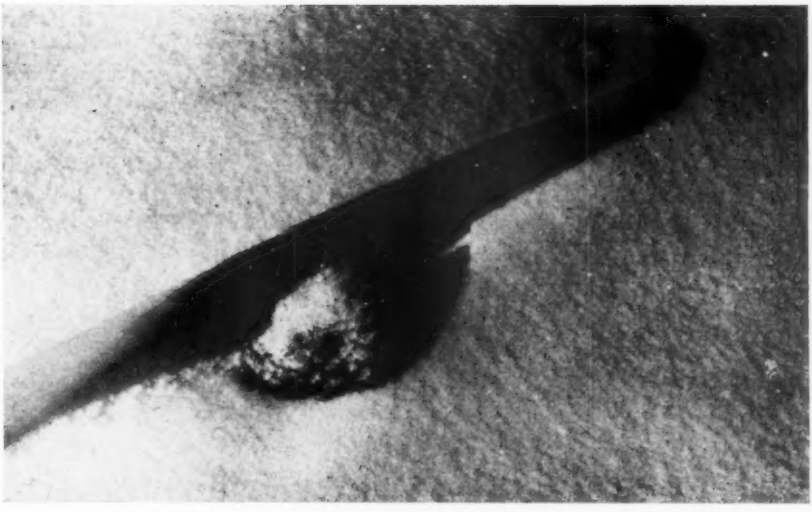


Fig. 2. Brown lemming dead on the snow surface, as commonly observed preceding the abrupt decline of the early spring of 1949.

Observations During 1949

On March 22 lemming tracks were numerous in the vicinity of Point Barrow. These tracks emerged from burrows in the snow, and practically all were made by *Lemmus*. Such snow tunnels apparently were used but once, for additional tracks were not noticed coming from them, and attempts to trap lemmings by making runway sets nearby were unsuccessful. The animals left the security of the snow to wander about on the crust. Whether they survived is not known, but later observations indicate that many did not. For several days following March 25, an effort was made to trap lemmings by digging a trench down to the tundra, where baited snap-type traps[1] were set near the sub-snow space. Lemmings were numerous, judging from the abundance of fresh droppings under the snow. This method failed entirely even though, when light snow-falls covered the area, lemming tracks were often observed near the traps. Subsequent observations indicate that lemmings are best trapped where unbaited runway sets can be made.

On March 26, following a period of high wind and cold weather, three brown lemmings were found dead on the surface of the snow, and from this time on numerous specimens were secured by searching for them on the tundra where their dark colour in contrast with the snow made them visible for a considerable distance (Fig. 2). The first snowy owl was seen on March 28.

A total of 46 lemmings was obtained in this manner prior to May 12, after which living animals were occasionally captured. The animals found dead weighed from 13 to 75 grams, with an average weight of 44 grams. Most of these animals were juveniles or subadults.

[1]Peanut butter was generally used as bait.

Four snowy owls were seen on April 4 near Point Barrow, and several others were seen the next few days during the course of a trip along the Inaru, Meade, and Topagoruk rivers, covering a distance of about 150 miles. On this trip a single brown lemming was captured (April 4), and a collared lemming was found dead on the surface of the snow (April 15). No other lemmings were seen.

From April 24 to May 7 the writer worked farther inland, beyond the limits of high lemming density. After May 7, upon return to the lemming area, dead brown lemmings were found increasingly more often on the snow surface. About May 15 the effect of the spring thaw was becoming apparent, and bare patches of tundra could be seen in favourably located areas. By May 17 the melting was appreciable, and it was only then possible to gain a real impression of the actual abundance of the brown lemmings. Their tracks became increasingly numerous in the snow surrounding the bare patches of tundra, and this snow was also honeycombed with their tunnels. The lemmings were very active around the open areas, but ran beneath the snow at the slightest provocation. Arctic foxes circulated from one of these snow-free areas to another in their attempts to capture lemmings, and predatory birds were also much in evidence. From May 20 to May 27 observations were made at Wainwright, about one hundred miles west of Point Barrow. It was found that brown lemmings were also abundant here, under similar conditions of spring thaw. Several specimens of brown lemming were secured.

By May 27 the tundra appeared alive with lemmings in the vicinity of Point Barrow, wherever there were snow-free areas. Dead lemmings were much in evidence, scattered over the bare tundra and surrounding snow, and occasional aggregations of lemmings were found, which had probably been made by foxes. Figure 3 shows the appearance of the tundra at this time.

On May 28 Dr. Laurence Irving and the writer collected lemmings along the margins of a large marshy area about a mile south of Point Barrow. Hundreds of lemmings were observed, most of them escaping under the unmelted snow. About 25 dead animals were picked up, including three collared lemmings, the only ones of their species seen at this time. The latter weighed 57, 78, and 91 grams. Dying brown lemmings were seen occasionally. The apparently normal animals collected were taken with a shot gun, since otherwise they escaped beneath the snow.

One of the most impressive things observed was the congregation of predatory birds and mammals in the areas where lemmings were most abundant. Arctic foxes were numerous, and their tracks were everywhere in evidence around the open tundra areas. Many dogs came out from Barrow village to feed on the dead and dying lemmings. Owls were numerous, and pomarine jaegers were abundant. Glaucous gulls were

present in smaller numbers over the tundra, although they were numerous along the coast.

Three living collared lemmings, the only ones seen on this date, were collected on May 29 where they were found among hundreds of brown lemmings. These animals weighed 12, 31, and 43 grams. The writer saw no conflicts between the animals of the two species; both occurred together in the same places, although collared lemmings were rare.

During the last days of May it was evident that larger brown lemmings were preponderant; apparently almost all breeding had ceased some weeks

Fig. 3. Appearance of the tundra at the time of highest lemming density.

before. The average weight of 91 animals collected during this time was 60.8 grams (10.5 to 95 grams).

There was a rapid decrease in lemming numbers from the last few days of May until early June. By June 6 practically all the lemmings had disappeared, presumably having died. On June 6 only 2 living animals were noted, where a week before hundreds were seen in the same period of time. Dead and dying animals were also absent, apparently all having been consumed, mainly by the jaegers which closely patrolled the open areas where dead lemmings could be found. At this time there was estimated to be from 30 to 40 pomarine jaegers per square mile of tundra in the Point Barrow area. Eight of these birds were collected on June 2, and all had brown lemmings in their stomachs.

As far as it was possible to recognize, there was no further decline in lemming numbers after early June, although the scarcity of the animals made observations of any kind difficult. By the latter part of the month,

when all snow had melted, evidence of the past abundance of the brown lemmings was everywhere. Nests were numerous, with large quantities of droppings around them (Fig. 4). There was a marked effect upon the tundra vegetation; in many places the tundra was practically denuded, and in other areas sedges cut during the fall or winter were washed up in windrows by the water from the melting snow (Fig. 5). The remaining lemmings were rarely seen, having established themselves in the relatively dry "owl mounds", where they apparently make burrows for the summer months. In favourable areas, particularly where sedges (*Carex* spp.) grew densely, typical runways were seen. Completely roofed-over runways were observed in certain areas where there was a dense lichen cover (Fig. 6). A few animals (*Lemmus*) were trapped in July by making runway sets with unbaited traps.

Intermittent observations during the remainder of the summer failed to disclose any change in the situation. Light snows in early October made it again possible to obtain some idea of lemming density (Fig. 7). Lemming tracks and other signs were scarce, and the observations made in the fall substantiated the opinion that lemmings were few. Snowy owls were very numerous during early October. On October 4 the writer estimated a density of about 8 to 10 owls per square mile in the vicinity of Point Barrow. These birds had almost entirely disappeared by the

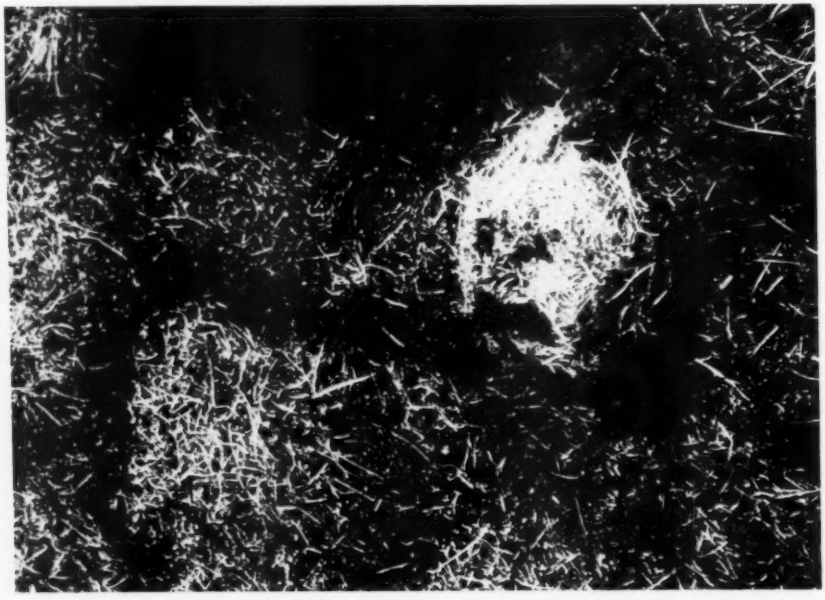


Fig. 4. Typical winter nest of the brown lemming, with abundant droppings, following the spring thaw of 1949.

Fig. 5. Sedges cut by lemmings during 1949, washed into windrows by the spring thaw.

Fig. 6. Roofed-over runways of brown lemmings, near Point Barrow, summer of 1949.

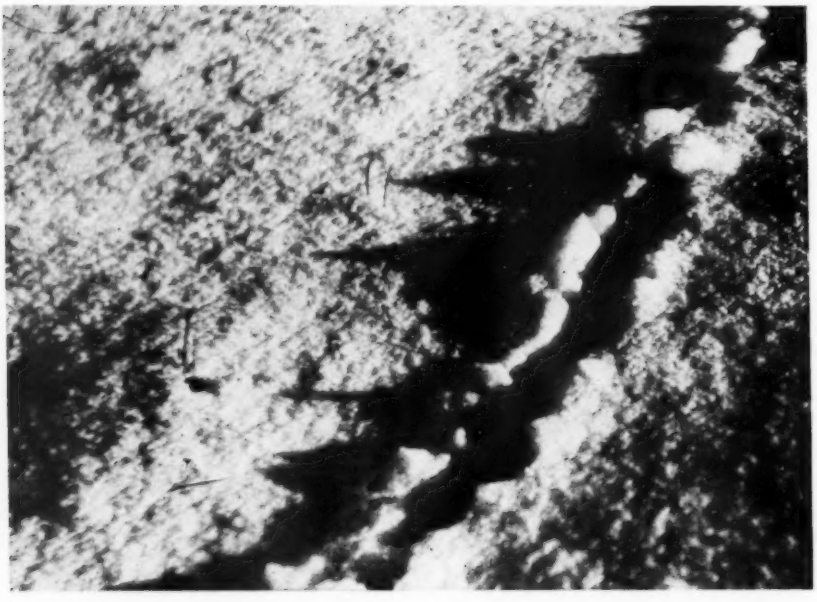


Fig. 7. Brown lemming runway as seen in the first light snow of autumn 1949, at Point Barrow.

end of the first week in November. The writer examined 99 owls collected after the decline had occurred, and found that 42 of these contained *Lemmus* remains in the stomach. A single *Dicrostonyx* skull was recovered. The bulk of these owls was collected during the month of October, 1949. From this it is obvious that the lemmings, though scarce, were by no means so rare that the owls were starving. The majority of these owls consisted of birds of the year, a high productivity having resulted from the earlier abundance of food.

Comparative Observations in 1950

In 1950 observations at Point Barrow were not begun until May 28, the time immediately preceding this having been spent inland beyond the limits of the previous lemming population peak. Extensive field observations in the vicinity of Point Barrow were made on May 29, and no sign of lemmings was discovered. In contrast to the conditions of the previous year, no snowy owls or jaegers were seen during the course of a trip which on the corresponding date in 1949 would have disclosed many of each. On May 30 there were four pomarine jaegers flying over an open lead about two miles off Point Barrow, but none was seen anywhere on the tundra. On June 4, when snow-free patches were numerous on the tundra, the writer travelled overland to a point about ten miles west of Point Barrow, and returned the same day. Some lemming droppings

and a few tunnels in the snow were found, but no animals. It is noteworthy also that no snowy owls or jaegers were seen. On June 8, however, when the spring thaw was well advanced, E. L. Schiller and the writer observed 4 snowy owls and a few pomarine jaegers in an area of numerous peat hummocks just west of Point Barrow. Here there were a few lemming tracks, and two animals (*Lemmus*) were captured. Lemming droppings were rather abundant on those hummocks in which burrows were located. The examination of fresh owl pellets from this area showed that these birds were feeding exclusively on lemmings, and brown lemmings were found in the stomachs of several pomarine jaegers. Both species of birds, however, were much fewer than they had been the previous year.

The observations of Daniel Q. Thompson, who spent the summer of 1950 investigating the ecology of lemmings in the Point Barrow region, substantiate the conclusion of the writer that the lemmings were very scarce. Mr. Thompson's observations also support the conclusion that both owls and jaegers were rare in the Barrow region during 1950. Only one nest of the pomarine jaeger was found during the summer of 1950, and only 4 owls, 2 young and 2 adults, were known to be in that vicinity. In contrast, the nests of both species were commonly observed during the early summer of 1949.

Discussion

Years in which lemming populations are very high have been known in North America, although they seem rarely to give rise to the more spectacular migrations seen in northern Europe. A few migrations have been reported, but they have never been studied by biologists. Consequently, no good comparison can be made between the fluctuations in North America and those in Eurasia. According to the definitions of Kalela (1949), lemming population changes recorded in North America do not necessarily follow the same pattern as those in Eurasia. More information is needed regarding "Proliferationsperiode" in North America, and the occurrences leading up to high density and migration. Little information is available on lemmings in Alaska, but several studies have been made in Canada. Among these are the reports by Soper (1928), D. Chitty (1939, 1938), H. Chitty (1943), H. Chitty and D. Chitty (1945), Chitty and Elton (1937), Chitty and Nicholson (1942), Sutton and Hamilton (1932), and Shelford (1943). Elton (1942) has summarized much of this work.

An approximate 4-year cycle of abundance has been established for the lemming on the Arctic Slope of Alaska. The last "high" was during the spring of 1946. According to very reliable Eskimo, only the brown lemming shows such violent fluctuation in numbers. In this region the collared lemming does not appear to attain an unusual density. There

are, however, reports of high densities of collared lemming in other parts of arctic North America. Sutton and Hamilton (1932, p. 65) described such an occurrence, and Soper (1928, p. 51) suggested that there might be an alteration of periods of abundance of the two species.

The true geographical extent of the high lemming density on the Arctic Coast of Alaska in 1949 could not be determined because of travel difficulties and the distances involved. However, incomplete observations allow at least some concept of this. Figure 1 gives the region over which it was known that the lemmings had reached a peak density. This extended from Point Lay, west of Point Barrow, to the Alaktak River, east of Point Barrow near Admiralty Bay. The animals were abundant to a distance of approximately 30 miles inland. Field work at Umiat on the Colville River, during the spring and summer of 1949, definitely established that lemmings were uncommon there. Only two specimens of *Lemmus* were obtained, and one of these was taken from the stomach of a rough-legged hawk nesting on the Colville River bluffs. Also, there was no visible evidence of any rodent activity attributable to lemmings, although certain other mouse-like rodents (*Clethrionomys rutilus*; *Microtus miurus*; and *M. oeconomus*) were rather common in this region. Kalela (1949) has discussed the simultaneous occurrence of high population densities in various small rodents, as observed in northern Finland. Elton (1942) also discusses species other than lemmings. At the north edge of the Brooks Range, where the writer spent much time collecting mammals, both species of lemmings were taken, but both were uncommon (Rausch, 1950). According to the local Inland Eskimo, the lemmings never reach high population densities in this region.

The apparent relationship of lemming abundance and decline to snowy owl migration has long been recognized. Gross (1947) reviews some of the literature on this. There is no definite knowledge, however, as to how these are interrelated. The banding of snowy owls on the breeding grounds during years of high owl and lemming densities prior to any southward owl "invasion" would perhaps clearly establish the source of such migrating owls, and allow a better understanding of what is involved. Although, as mentioned above, it is evident that the owls had left the Arctic Coast by early November of 1949, it is not known where they went, nor what part they played in the invasion into the southern part of the continent. In any case, snowy owls were rare over the Arctic Slope of Alaska during the winter of 1949-50.

It is perhaps worthwhile to note that the large proportion of young birds in the owl population, resulting from a year of unusual nesting success, might have played an important part in this migration. The writer obtained more than 80 great horned owls (*Bubo virginianus*) trapped during the winters of 1946 and 1947 at the State Game Farm, Poynette, Wisconsin; of these practically all were immature birds which

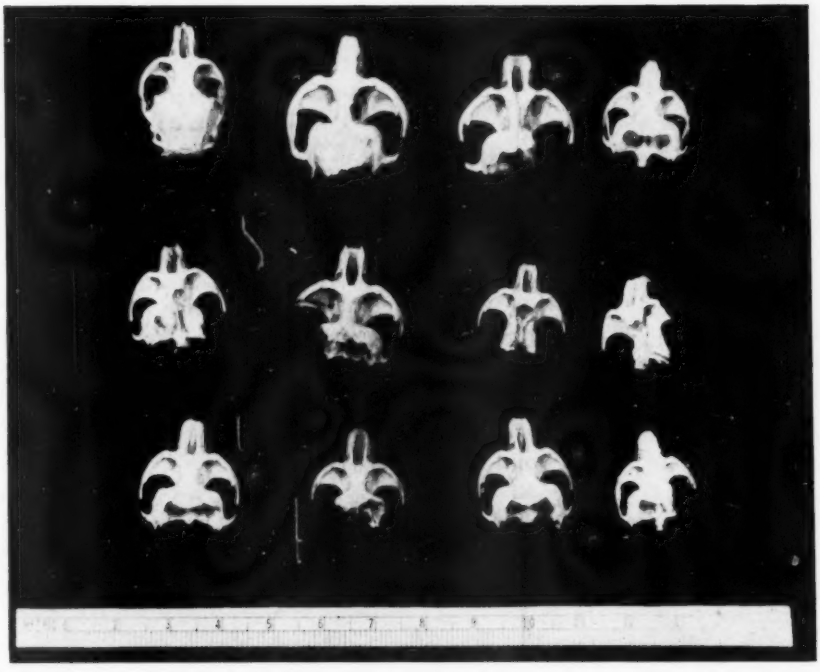


Fig. 8. Skulls of lemmings taken from snowy owl and pomarine jaeger stomachs, showing typical damage.

apparently were migrating prior to any localization. It could perhaps be suggested that an unstable owl population might result when many young are reared because of the unlimited food supply available during years of high lemming density, and that this might in some way contribute to the "invasion" phenomenon.

It is recognized by the Eskimo that jaegers become abundant during the years of high lemming density. The pomarine jaeger appeared early in May in the spring of 1949, and became increasingly abundant up to the time of nesting. Although long-tailed and parasitic jaegers also were present they did not appear in the Barrow region until later, and were relatively few in number. In spite of the statements of McCabe and Racey (1944, p. 465), the jaegers are effective predators upon lemmings. The pomarine jaeger usually crushes the back of the skull of animals captured in the manner of the snowy owl. The writer has collected jaegers of all three species and has found no indication that their beaks are "weakly flexible" and "soft" as McCabe and Racey maintain. Figure 8 shows a collection of lemming skulls from owl and pomarine jaeger stomachs; the extent of damage is evident. Apparently the skull is not crushed when the lemming is picked up already dead.

Arctic foxes were unusually numerous during the winter of 1949-50. In addition to abundant tracks on the tundra and actual animals seen, the trapping results of the Coast Eskimo bear this out. The writer examined

the stomachs of 79 foxes trapped up to January of 1950. Of these, about 10 per cent contained lemmings; however, most were empty, so no reliable observations could be made. A moderately high fox population persisted into the summer of 1950.

According to the Eskimo, not only are "lemming years" particularly associated with snowy owl, jaeger, and arctic fox abundance, but also with good sea hunting. It was of interest that walrus hunting was unusually good in the Barrow region in the summer of 1949.

It is obvious that during the spring of 1949 the population of the brown lemming on the Arctic Coast of Alaska reached peak proportions, with a subsequent abrupt decline resulting from a heavy mortality. The suddenness of this decline found the writer unprepared for suitable pathological studies, so only superficial observations were made. It was noted that dying lemmings observed on the surface of the snow usually manifested considerable spasmodic or convulsive activity just prior to death. Although the presence of more obscure conditions was not determined, it was evident from the examination of numerous animals, secured both alive and after death, that there were no grossly visible lesions such as might be expected from bacterial infections. No effort was made to determine the presence of viruses or of other organisms.

Weber (1950, p. 553), in reference to this decline, stated that "When the lemmings increase too greatly they consume plants faster than they can grow in this cold climate and so starve themselves." While there is no doubt that the tundra vegetation was reduced by the lemmings, there is nothing tangible to indicate that the decline in numbers resulted from starvation. The relationship, if any, of vegetation reduction to lemming mortality can only be determined by controlled long-range observations.

Certain observations on the breeding and age composition of the population were derived from the animals examined during the spring of 1949. The absence of very young animals indicated little breeding for some weeks prior to the decline. The breeding condition of 139 lemmings was determined prior to and during the time of decline, and no evidence of reproductive activity was observed. Of these, 59 were females. A few females showed perforate vaginae, but none were pregnant, and there were no placental scars in the animals examined. The breeding condition of the males was not so readily determined, but apparently testicular development was not normal. The greatest testis length was 12 mm., and descent was not complete.

Helminth parasite infections could not be considered abnormal, nor detrimental to the condition of the animals infected. In fact, parasitism was very light when compared with that usually observed in microtine rodents. As concluded for other species (Rausch and Tiner, 1949), there does not appear to have been any increase of helminth parasites under conditions of high population density. A summary of parasites found in

the animals examined prior to and during the decline are shown in the following table.

Host	Number examined	Parasite	Number infected
Lemmus	139	*Hymenolepis horrida*	15
		Andrya primordialis	4
		Paranoplocephala infrequens	2
		Taenia temuicollis (larval)	1
Dicrostonyx	13	*Hymenolepis horrida*	2
		Andrya primordialis	2
		Syphacia arctica	5

Endoparasites recorded from lemmings in the Point Barrow region. All are cestodes but *S. arctica*, which is a nematode. Helminth names are according to the most recent nomenclature.

The factors involved in the high mortality which often follows high population densities of lemmings and other microtine rodents can only be determined by controlled long-term studies. These observations will be continued and, if circumstances permit, a carefully planned investigation of lemming mortality will be carried out during the next time of high lemming density. Presumably, this will occur during the spring of 1952.

References

Chitty, D. 1938. "Canadian Arctic wildlife enquiry, 1936-37". *J. Anim. Ecol.* Vol. 7, pp. 381-394.

1939. "Canadian Arctic wildlife enquiry, 1937-38". *J. Anim. Ecol.* Vol. 8, pp. 247-260.

Chitty, D., and M. Nicholson. 1942. "Canadian Arctic wildlife enquiry, 1940-41". *J. Anim. Ecol.* Vol. 11, pp. 270-287.

Chitty, D., and C. Elton. 1937. "Canadian Arctic wildlife enquiry, 1935-36". *J. Anim. Ecol.* Vol. 6, pp. 368-385.

Chitty, H. 1943. "Canadian Arctic wildlife enquiry, 1941-42". *J. Anim. Ecol.* Vol. 12, pp. 163-172.

Chitty, H., and D. Chitty. 1945. "Canadian Arctic wildlife enquiry, 1942-43". *J. Anim. Ecol.* Vol. 14, pp. 37-45.

Elton, C. 1942. 'Voles, mice and lemmings'. Oxford, pp. 1-496.

Gross, A. O. 1947. "Cyclic invasions of the snowy owl and the migration of 1945-1946". *Auk.* Vol. 64, pp. 584-601.

Kalela, O. 1949. "Über Fjeldlemming-Invasionen und andere irreguläre Tierwanderungen. Mit einer Übersicht der Kleinnagergradationen in Finnisch-Lappland 1900-1948". *Ann. Zool. Soc. "Vanamo"*. Vol. 13, pp. 1-90.

McCabe, T. T., and K. Racey. 1944. "The parasitic jaeger". *Auk*, Vol. 61, pp. 465-466.

Rausch, R. 1950. "Notes on microtine rodents from the Brooks Range, Arctic Alaska". *J. Wash. Acad. Sci.* Vol. 40, pp. 133-136.

Rausch, R., and J. D. Tiner. 1949. "Studies on the parasitic helminths of the North Central States. II. Helminths of voles (*Microtus* spp.). Preliminary report." *Amer. Midl. Nat.* Vol. 41, pp. 665-694.

Shelford, V. E. 1943. "The abundance of the collared lemming (*Dicrostonyx groenlandicus* (tr.) var. Richardsoni Mer.) in the Churchill area, 1929 to 1940". *Ecology*, Vol. 24, pp. 472-484.

Soper, J. D. 1928. "A faunal investigation of southern Baffin Island". *Bull. Nat. Mus. Can.* No. 53 (Biol. Ser. No. 15), pp. 1-143.

Sutton, G. M., and W. J. Hamilton. 1932. 'The exploration of Southampton Island, Hudson Bay'. Part II, Zoology. Section 1, "The mammals of Southampton Island". *Mem. Carnegie Mus.* Vol. 12, pp. 1-111.

Weber, N. 1950. "The role of lemmings at Point Barrow, Alaska". *Science*, Vol. 111, No. 2890, pp. 552-553.

PHYSICAL OCEANOGRAPHY OF THE NORTH POLAR SEA

By **H. U. Sverdrup***

In 1879 when Commander De Long sailed north through Bering Strait on his ill-fated ship, the *Jeannette*, he hoped to discover new land. Although the north coast of Siberia had been charted by the Great Northern Expeditions sent out by Peter the Great in the first half of the 18th century and large parts of the archipelago to the north of Canada had been mapped by the expeditions searching for Franklin, the greater part of the Arctic was still unexplored. The northward extent of Greenland and of the island groups to the west of Greenland was unknown and the opinions of geographers as to the possible distribution of land and sea were divided. Many joined the German geographer, Petermann, in the hypothesis that the known part of Greenland represented only a portion of a large land mass which extended across the North Pole to Wrangel Land, now Wrangel Island (Ostrov Vrangelya). Others believed that the unknown region was one of numerous islands separated by shallow waters.

The drift of the *Jeannette* from 71°35N., 175°06W. to 77°15N., 154°59E. demonstrated that Wrangel Land was not continuous with Greenland. However, as the *Jeannette* remained in shallow water during the course of her two-year drift, the possibility that the unknown Arctic was an island region still existed.

In 1884 a number of objects from the *Jeannette*, including pieces of clothing marked with the names of members of the expedition, were found on an ice floe off southwestern Greenland. Professor H. Mohn in an article in the Norwegian *Morgenblad* suggested that the ice floe on which the articles were found had been carried by currents across the "Polar Sea". He collected other evidence as well, including the finding of driftwood from Siberian regions and implements of Alaskan Eskimo on the coast of Greenland, to substantiate his conclusion.

Professor Mohn's theory suggested to Fridtjof Nansen the idea that a large part of the unknown Arctic could be explored and the North Pole reached by allowing a ship, built to withstand the pressure of the ice, to be caught in the ice in the region where the *Jeannette* had been abandoned and letting her drift with the currents until released off the coast of Greenland.

Nansen's suggestion was regarded with scepticism by most arctic explorers. Some claimed that no ship could be built which would not be crushed by the ice. Others believed that the unknown waters were shallow and full of islands and that a ship might become hopelessly stuck in regions from which it would be impossible to return safely. Still others

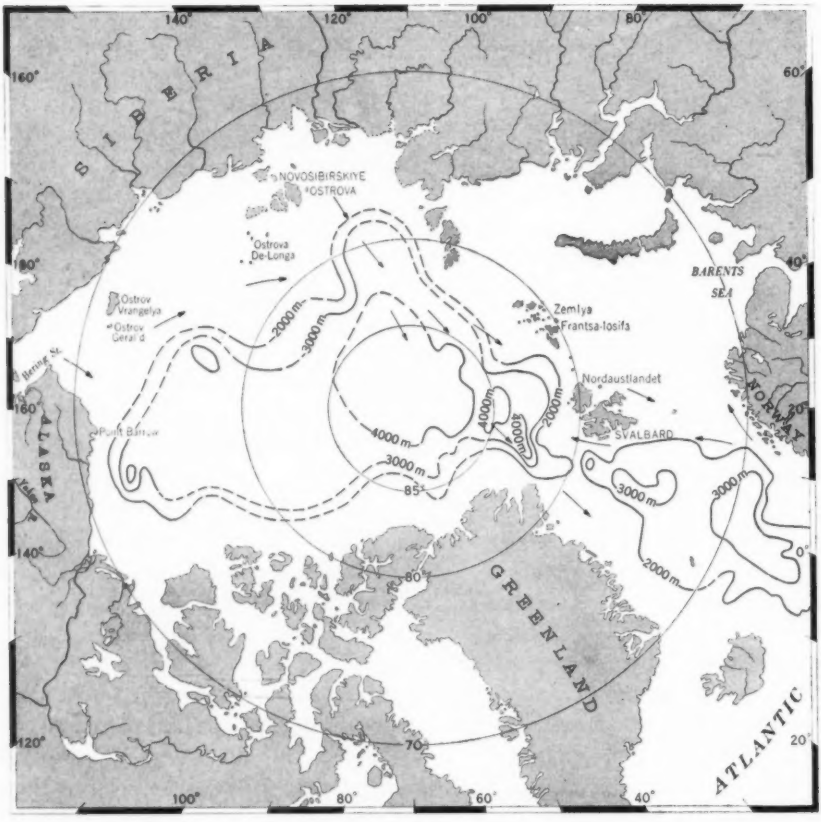
*Director, Norsk Polarinstitutt, Oslo, Norway.

would not believe that the ice drifted across the unknown areas. However Nansen was not discouraged and he proceeded to carry out his plan. The *Fram*, which fulfilled all Nansen's requirements, was designed by Colin Archer and during the years 1893-6 completed the drift from the New Siberian Islands (Novosibirskiye Ostrova) to Spitsbergen.

In preparing his plans, Nansen had been right on every point except one. As Nansen, like everyone else, had expected to find shallow water in the North Polar Basin, the *Fram* was not equipped to take soundings in depths exceeding 1900 metres. She carried only some simple hand winches for soundings, 200 metres of bronze wire, about 1200 metres of single steel cord, and about 1900 metres of hemp line. Soon after the drift had started the depth was so great that even the hemp line was not long enough and new sounding lines had to be made from one of the ship's thick steel wire cables. This was a long and arduous task because the cable had to be separated into single strands which were then twisted into short pieces and soldered together. When the new line was completed eleven successful soundings were carried out under most difficult conditions. These gave depths ranging from 3400 to 4000 metres, showing that there was a deep basin in at least part of the North Polar Sea.

The discovery of the deep Polar Basin was the major geographical discovery of the *Fram* expedition. Since then our knowledge of the extent of this basin has increased only very slowly. The boundaries of the Polar Sea appear now to be fairly completely explored, and vague reports of land seen beyond the established boundaries have repeatedly been found to be erroneous. For some time the hypothesis of the tidal expert, R. A. Harris, that an extensive land mass should exist between the North Pole and Alaska attracted considerable attention, but results of tidal observations on the *Maud* expedition of 1922-4 removed the arguments on which Harris' hypothesis was based. Amundsen and Ellsworth flew from Spitsbergen to Alaska in 1926 in the dirigible *Norge* and, as expected, saw no land. Since then numerous flights have been made over different sections of the Polar Sea and nothing but pack ice has been reported.

Soundings are still few and far between, but the work accomplished on the Papanin North Polar Expedition in 1937-8 and during the drift of the *Sedov* in 1938-40 has added considerably to our information as to depths to the north of Spitsbergen and Franz Josef Land (Zemlya Frantsa-Iosifa), from where depths around 5000 metres have been reported. In latitude 86°26′5N., longitude 38°25′0E. the *Sedov* did not reach the bottom with a line of 5182 metres, but in an adjacent locality, 86°23′5N., 38°35′0E., bottom was reached at 4977 metres. The greatest depth sounded on the Papanin expedition was 4395 metres in 88°07N., 4°00W. In 1927 Sir Hubert Wilkins obtained a sounding in excess of 5000 metres, using sonic methods, to the north of Wrangel Island, but this result appears doubtful



Bathymetric chart of the North Polar Sea according to Wüst, showing the 2000-, 3000-, and 4000-metre contours. The arrows indicate the direction of the surface currents.

because in 1941 the Russian aviator Cherevichny obtained a maximum depth of 3430 metres in nearly the same locality.

W. Wüst has revised the bathymetric chart of the North Polar Sea, but the recent soundings have not altered the presentation of the larger features, which was prepared by Fridtjof Nansen in 1904. However, much work remains to be done before the width of the continental shelves surrounding the basin and the details of the topography of the floor of the basin can be determined.

The deep Polar Basin is an elongated depression surrounded by wide continental shelves. The major axis of the depression is about 1600 nautical miles long and runs from North East Land (Nordaustlandet), Svalbard, to Alaska. The minor axis is about 800 nautical miles long. Off the coast of eastern Siberia the continental shelf is up to 500 miles wide and is very shallow, the 50-metre contour being found 300 miles from land. Off the northern coast of Alaska the shelf is only 50 to 100

miles wide and off the Canadian Archipelago it is probably about 100 miles wide, but soundings from this region are lacking. The area of the Polar Sea, including the Barents Sea, is about 7.25 million square kilometres (2.8 million square miles), and the volume of water is about 11.65 million cubic kilometres (2.8 million cubic miles). The average depth is about 1600 metres (1 mile) and the maximum depth is probably about 5000 metres (3.1 miles).

Currents

The main features of the circulation of the waters of the Polar Sea are a surface overflow of cold arctic water of low salinity and a subsurface inflow of warmer and more saline Atlantic water. This exchange of water takes place through the wide opening between Spitsbergen and Greenland, the other openings being too narrow and too shallow to be important. Bering Strait is of minor importance only; there, over the year, water from Bering Sea flows north through the Strait.

The major outflow of surface water takes place off east Greenland and is to a great extent maintained by the fresh water which is discharged into the Polar Sea by the large Siberian and Canadian rivers. The Yukon River also contributes since in spring and summer its waters flow north through Bering Strait along the Alaskan coast. The outflow of cold, low-salinity water from the Polar Sea exercises a widespread influence upon the oceanographic conditions in the northern North Atlantic and upon weather conditions over that ocean, and it is possible that year to year differences in weather conditions are related to variations in this exchange.

The main inflow of water into the Polar Sea takes place to the north of Spitsbergen. Atlantic water of the Gulf Stream System enters the North Sea to the north of Scotland and flows along the west coast of Norway. Off the north coast of Norway the current branches, one branch flowing east along the Murmansk coast, the other flowing north and passing along the west coast of Spitsbergen. To the north of Spitsbergen, in about latitude 80°N., the current submerges and continues as a subsurface current into the Polar Sea. Measurements of temperature and salinity on the *Fram* and *Sedov* expeditions have shown that water of Atlantic origin is found to the north of the New Siberian Islands, and observations in latitude 80°38N., 179°02W. by Cherevichny, with the Russian aircraft N-169, in 1941 show presence of Atlantic water near the "Pole of Inaccessibility."

The character of the deep-water circulation in the Polar Basin is not known though this water has been shown to be formed in the Norwegian Sea.

The surface currents of the Polar Sea depend to a great extent upon the winds. During the drift of the *Fram*, Nansen observed that the ice

was not carried along in the direction in which the wind blew but that the ice drift deviated, on an average, 28 degrees to the right of the direction towards which the wind was blowing. From the many entries in Nansen's diaries it is evident that in his leisure hours he often speculated upon the cause of this anomaly. He arrived at the conclusion that the deviation of the ice drift must be ascribed to the effect of the rotation of the earth, which in the northern hemisphere tends to deflect any moving body to the right. Nansen reasoned further that the ice would set the water directly underneath it in motion and that the water would then move to the right in relation to the ice drift; this layer would set the next layer in motion, again to the right, and so on. Similar conditions could be expected in the open sea, and Nansen therefore reasoned that, in general, a wind current is directed to the right of the wind direction at the sea surface; with increasing depth, the current is deflected farther to the right and decreases in speed because of the effect of frictional forces. These ideas as to the character of wind currents were entirely new to oceanography. A few years after his return from the Arctic, Nansen discussed his ideas with Professor V. Bjerknes who called in one of his students, Mr. V. W. Ekman, a capable mathematician. Ekman expressed Nansen's theories mathematically and in 1902 published his classical paper on the theory of wind-driven currents in the ocean. The essential features of this theory are still valid.

This discovery of the character of wind-driven currents is an outstanding example of the fact that discoveries made in the Arctic may have a bearing on our general understanding of natural phenomena. In the Arctic a trained observer has nothing to distract him. He lives day after day and week after week with the events which happen around him and can study them with an intensity which is rarely possible under other conditions. The drift of the *Fram* provided particularly favourable conditions for studying wind drift because the ship was moving with the ice, its position could be determined accurately at intervals of a few days, exact and continuous wind records could be obtained, and the results could be analysed immediately. These conditions made it possible for Nansen to carry out observations with an accuracy which could never have been achieved in the open sea and gave him the opportunity to consider his results so carefully that he could evaluate the various factors involved.

There remained, however, one discrepancy between Ekman's theoretical conclusions and Nansen's observations. According to the theory, the surface wind current in the open sea should deviate 45 degrees from the wind direction, and this conclusion has subsequently been borne out by observations of ocean currents. But the ice drift in the Polar Sea deviated on an average only 28 degrees to the right. Nansen attributed

this discrepancy to the resistance of the ice, a factor which was later investigated during the drift of the *Maud* from Herald Island (Ostrov Geral'd) to the New Siberian Islands.

As the wind never blows with uniform speed and direction over very large areas, ice in neighbouring regions of the Polar Sea moves in different directions and with different speeds. Because of these differences in motion the ice in some areas is torn apart and in others it is jammed together. In summer and early fall the ice moves fairly freely because the numerous openings which are formed in early summer do not freeze over; at the same time the ice decreases in thickness because of melting. In winter and spring, on the other hand, the ice is packed solidly together and has attained its maximum thickness. The more solid the ice cover, the greater will be the resistance against the motion. Where the resistance is great the angle of deflection will be small and the speed of the ice drift will be slow in relation to the wind speed. Observations on the *Maud* showed that the angle of deflection varied during the year from a minimum of 17 degrees in April to a maximum of 40 degrees in August and that the ratio between the speed of the ice and the speed of the wind varied between 0.014 in April and 0.024 in August.

The direction of the average surface drift depends upon the direction of prevailing winds. On an average for the year the prevailing winds show a clockwise, anticyclonic circulation over the Polar Sea, with the centre of the anticyclone probably located to the north of Alaska in about latitude 85°N. Nothing is known about the ice drift to the north of the Canadian Archipelago, but to the north of Alaska and eastern Siberia it is directed towards the west, turning somewhat towards the north off the central arctic coast of Siberia. To the north of Spitsbergen, the drift takes a southerly direction, and here there is evidence of a southerly current which is independent of the prevailing winds and which increases in speed as it approaches the coast of eastern Greenland, carrying large quantities of ice to the south.

No strong winds have ever been observed over the ice-covered Polar Sea. It appears very improbable that the average wind speed during 24 hours ever exceeds 15 metres per second in January and 10 metres per second in August. The corresponding maximum values of the ice drift cannot be expected to exceed 30 kilometres, or 16 nautical miles, in 24 hours. These figures apply to conditions at distances greater than about 50 miles from land where the ice movement is not hindered by land masses.

In fact, the average surface currents are very weak. According to the drifts of the *Karluk*[1], the *Jeannette*, and the *Maud*, the ice drift from Point Barrow, Alaska, to De Long's Islands (Ostrova De-Longa) is at a

[1]The *Karluk*, one of the vessels of the Canadian Arctic Expedition, 1913-8, was caught in the ice at approximately 70°30N., 147°40W. in August, 1913 and in the following five months drifted to 72°08N., 173°50W. where she sank.

rate of about 1.0 nautical miles per day. The drifts of the *Fram* and the *Sedov* showed that the average speed of the drift from the New Siberian Islands to Spitsbergen is only slightly faster. Both the *Fram* and the *Sedov* drifted at greater speed, about 1.5 nautical miles per day, when they approached the opening between Spitsbergen and Greenland south of 80°N. The drift of the Papanin party from the region of the North Pole to latitude 71°N. off eastern Greenland averaged about 1.5 nautical miles per day.

Temperatures and Salinities

The surface layer of the Polar Sea has a low salinity because of the large discharge of fresh water from the rivers which flow into the Basin. As practically no evaporation takes place from the Polar Sea the small annual precipitation also contributes to the dilution of the surface layer. The total addition of fresh water from all sources is approximately 8300 cubic kilometres (2000 cubic miles) per year.

The effect of the rivers is particularly marked in summer, the time of the greatest discharge, when salinities below 3 parts per thousand may be found at distances of 60 miles from the delta of the River Lena. The greater the distance from the mouth of the river, the more thoroughly the river water has been mixed with the sea water; but even at a distance of 300 miles from the Siberian coast the salinity in the surface layer is below 30 parts per thousand. The salinity probably increases more or less regularly towards the Spitsbergen-Greenland opening where values between 32 and 33 parts per thousand prevail.

The temperature of the surface layer the year round is near freezing point, that is, -1.5° to -1.6°C. In winter, when the thickness of the ice increases by freezing and when every opening which is formed under the action of the wind immediately becomes covered by young ice, a completely homogeneous surface layer of water about 30 metres thick is developed. When ice freezes the greater part of the salts remains in the water and freezing therefore causes an increase in salinity of that water which is in direct contact with the ice. An increase in salinity means an increase in density; the denser water sinks and is replaced by water of slightly lower salinity from a greater depth. Thus the process of freezing maintains convection currents in the surface layer and provides a mechanism by which the surface layer becomes thoroughly mixed. The intensity of the mixing is so great that in winter the entire surface layer moves both in the same direction and at the same speed as the ice drift.

In summer, when the ice is melting, the meltwater reduces the salinity in the openings between ice floes and of the water that is in direct contact with the ice. The temperature at the surface rises to nearly 0°C in summer, but at a depth of 20 to 30 metres it remains close to the freezing

temperature which was established during the preceding winter. The wind current in the surface layer decreases with depth and turns to the right, relative to the ice drift.

On the continental shelf off the coast of eastern Siberia the surface layer is very distinct, and the transition between it and the deeper waters is nearly discontinuous. In a vertical distance of less than 10 metres the salinity increases from about 29 to 33 parts per thousand, and the temperature increases by a few tenths of a degree. The density of the water increases from about 1.024 to about 1.027. At greater distances from the Siberian coast little is known about the sharpness of the lower boundary of the surface layers. The observations of the *Fram* clearly show that the surface layer is distinct and subject to a marked annual variation in temperature and salinity, but observations were not taken at sufficiently close intervals of depth for detailed examination. They do demonstrate, however, that the salinity of the surface layer increases towards Spitsbergen and it may therefore be expected that the rapid increase in salinity and density below the surface layer is less pronounced.

The increase in salinity and temperature below the top layer can be ascribed to the inflow of Atlantic water. When this water enters the Polar Sea its temperature is a few degrees above freezing and its salinity is nearly 35 parts per thousand. This water, however, has a density of nearly 1.028 which is considerably greater than that of the surface waters of the Polar Sea. When entering into the Polar Sea the Atlantic water therefore sinks below the Arctic water and gradually becomes mixed with the latter. Nothing is known as to the exact manner in which this Atlantic water spreads: but according to the observations of the *Fram* and the *Sedov* expeditions the Atlantic water can still be recognized to the north of the Siberian Islands by temperatures above 0°C at depths between 300 and 800 metres and by a slightly higher salinity.

The deep water of the Polar Sea is extremely uniform. According to Nansen's observations, it has a temperature between -0.8° and -0.9°C, increasing very slightly towards the bottom. Originally Nansen believed that the increase of the temperature towards the bottom was the effect of heat flow from the interior of the earth. Later on it was shown that since water is slightly compressible, its temperature must increase a little if it is brought adiabatically (without adding or subtracting heat) under higher pressure. The observed increase in temperature towards the bottom corresponds exactly to the adiabatical effect and renders, therefore, no evidence for heating through the ocean bottom.

Nansen's original values for the salinity were somewhat too high, but he subsequently revised them and arrived at the conclusion that the salinity was the same as that of the deep water of the Norwegian Sea, that is, about 34.94 parts per thousand. This value was confirmed by data

collected at several stations in the Polar Sea on the *Nautilus* expedition in 1931.

In fact Nansen concluded that the character of the deep water in the Polar Basin corresponded in every respect to that of the Norwegian Sea at a depth of 1200 to 1500 metres. The *Nautilus* observations indicated a similar depth, but from a re-examination of all available information Wüst concludes that the depth is 1750 to 2000 metres. It seems certain that the deep water of the Polar Basin is formed in the Norwegian Sea by the cooling, mixing, and sinking of surface water and that it then flows across the ridge separating the Norwegian Sea from the Polar Sea. This ridge, which approximately follows the parallel of 80°N., has not been sounded in its entire length, only the half of the ridge closest to Spitsbergen being well known. In this part the shallowest soundings give depths less than 700 and 800 metres. It therefore seems probable that the ridge is somewhat lower nearer Greenland where soundings indicate a depth of about 1800 metres, and that the inflow of water takes place through the Greenland side of the opening.

In conclusion it should be emphasized that our information about the character of the waters is available only from the Siberian-European side of the North Polar Basin. The larger region to the north of the American Continent is still unknown.

References

De Long, E. (ed.) 'The voyage of the *Jeannette*'. 911 pp. Boston, 1884.

Ekman, V. W. "Om jordrotationens inverkan på vindströmmar i hafvet". *Nyt Mag. for Naturvidenskab*, Vol. 40, No. 1 (1902) pp. 37-63.

Harris, R. A 'Arctic tides'. U.S. Dept. of Commerce and Labor, Coast and Geodetic Survey, 103 pp. Washington, 1911.

Nansen, F. 'Farthest north'. 1301 pp. New York, 1897.

"The oceanography of the north polar basin". 'The Norwegian North Polar Exped., 1893-1896'. Scientific Results, Vol. 3, 427 pp. Christiania, 1902.

"The bathymetrical features of the north polar seas, with a discussion of the continental shelves and previous oscillation of the shoreline". 'The Norwegian North Polar Exped., 1893-1896'. Scientific Results, Vol. 4, 232 pp. Christiania, 1904.

Sverdrup, H. U. "The wind-drift of the ice on the North-Siberian shelf". 'The Norwegian North Polar Exped. with the *Maud* 1918-1925'. Scientific Results, Vol. 4, No. 1, 46 pp. Bergen, 1928.

"The waters of the North-Siberian shelf". 'The Norwegian North Polar Exped. with the *Maud* 1918-1925'. Scientific Results, Vol. 4, No. 2, 131 pp. Bergen, 1929.

"Oceanography". 'Scientific results of the *Nautilus* exped. 1931'. Vol. 2, No. 1, pp. 16-63. Cambridge, Mass., 1933.

Wüst, G. "Die morphologischen und ozeanographischen Verhältnisse des Nordpolarbeckens". 'Veröffentlichungen des deutschen wissenschaftlichen Instituts zu Kopenhagen'. Reihe I: Arktis, No. 6. Gebrüder Borntraeger, Berlin-Zehlendorf, 1942.

RECENT STUDIES OF THE LAPPS

THE LAPPS. *By* BJÖRN COLLINDER. *Princeton: Princeton University Press for the American-Scandinavian Foundation, 1949. 8½ x 5½ inches; 252 pages; maps and illustrations. $3.75.*

THE SKOLT LAPP COMMUNITY SUENJEL SIJD DURING THE YEAR 1938. *By* KARL NICKUL. *Stockholm: Hugo Gebers Förlag for the Nordic Museum, 1948. 12¾ x 9¾ inches; 90 pages, 64 plates, maps and diagrams. Swedish kroner 35.00.*

The successful herding of reindeer by the Lapps for many centuries is an example of the effective exploitation of an arctic and subarctic environment. For this reason, and because of the influence of the Lapps on the Alaskan and Canadian reindeer industry, up-to-date information about this highly resourceful and intelligent people will be of interest to readers of *Arctic*. Such information is available in English in 'The Lapps' by Björn Collinder, Professor of Finno-Ugric Languages at the University of Uppsala, Sweden, and 'The Skolt Lapp community' by Karl Nickul, a Finnish geodesist who is Secretary of Lapin Sivistysseura (The Society for the Promotion of Lappish Culture), Helsinki. These two books complement each other and can profitably be read together. Both the American-Scandinavian Foundation and the Nordic Museum, Stockholm, have done a real service to arctic anthropology by making these studies available.

The term "Lapp" covers a number of related peoples living in an area stretching from western Norway to Russia's Kol'ski Poluostrov (Kola Peninsula). Professor Collinder gives both a broad survey of the ways of life of the various Lapp communities and brings out the important differences among them in language, clothing, religion, and reindeer herding methods and other phases of the subsistence pattern. Professor Collinder's most detailed observations are based on the Scandinavian reindeer nomadic Lapps, with whom he has spent considerable time studying their language.

Believing that "an understanding of the geography [of the land of the Lapps] is necessary to an understanding of the history, condition, and future of the Lapp people", Collinder carefully analyses their unusual environment. He contrasts Lapland, "the territory where the Lappish language is spoken," with the rest of the Arctic as to temperature, agricultural possibilities, and topography. Because of the influence of the Gulf Stream System and the absence of cold arctic currents, the Scandinavian Lapps have enjoyed climatic advantages not shared by other circumpolar peoples dwelling at similar latitudes.

Professor Collinder's interest in ethnological reconstruction is evident throughout 'The Lapps', particularly in the chapters devoted to language, clothing, dwellings, reindeer herding, and religion. Diffusion of Scandinavian elements into the Lappish culture is discussed at length. Many Lappish cultural elements are paralleled among other northern peoples. For instance, Lappish folktale motifs, as summarized on pp. 183-4, seem similar to those of the Reindeer Chukchi.[1] Like the Eskimo, the Lapps indulge in wrestling matches and there is a popular tradition that formerly they, too, killed aged tribal members with their own consent when they were no longer able to keep up with nomadic migrations. Shamanism was the Lapps' aboriginal religion and their adaptation of the Christian religion, Laestadian Lutheranism, seems to have preserved such arctic shamanistic characteristics as ecstasy, individual confession, and trance. Collinder states that the bear rituals of the Lapps were similar to those practised by the Voguls and Ostyaks of northwestern Siberia. As would be expected, Lappish reindeer herding methods are in many ways like those used by other reindeer nomads.[2]

[1]See Kardiner, A. 'The individual and his society', Columbia University Press, 1939, p. 125, for a brief discussion of Reindeer Chukchi folk tales; also Bogoras, W. "The Chukchee", *Mem. Amer. Mus. Nat. History*, Vol. 11 (1904-9).

[2]For a comparison of Lapp herding methods with those of other reindeer nomads, see Hatt, G. "Notes on reindeer nomadism", *Mem. Amer. Anthropological Ass.*, Vol. 6 (1919) pp. 75-133.

Because of the importance of reindeer in the economy of many Lapp groups, three chapters of the book are devoted to this subject: "The reindeer and its domestication", "The dog and the enemies of the reindeer", and "Reindeer breeding". Collinder's "catastrophe theory", which attempts to account for extreme fluctuations in herd size, seems plausible and worthy of further study.

In the chapter, "The history of the Lapps", the author shows how political events in Scandinavia and Russia have influenced Lappish history. While the effects of these events were occasionally detrimental to the Lapps, the humanity and wisdom with which the Scandinavian nations protected (and continue to protect) the hereditary rights of the nomads are impressive. The Swedish government made it clear to its colonists in the early seventeenth century that "the nomads should not be molested or ousted" and that Lapland was big enough for both reindeer breeding and agriculture. Today, the Swedish Lapps are in a strong economic position because Sweden has granted them a legal monopoly of the reindeer breeding industry. This policy, and the fact that it was formulated with the help of nomadic Lapps, is an important Swedish contribution to the solution of world minority problems.

European travellers and scientists have been interested in the Lapps for centuries and Collinder has analysed "ancient and modern opinions of the Lapps". Some of these observations seem remarkably penetrating in the light of recent anthropological research. For example, both Tacitus and Procopios, writing in the first and sixth centuries, state that the Lapp women take part in the hunting together with the men. In 1949 the reviewer witnessed the relatively slight division of labour between men and women among the Karesuando and Kautokeino reindeer nomads.

Anthropologists will feel 'The Lapps' suffers from its lack of a systematic presentation of the Lappish social structure and will find Collinder's description of the Lappish life cycle defective because it concentrates on the formal education given to Lapps in Swedish schools rather than on native child rearing practices.

One of the Lapp groups mentioned in Collinder's general summary, the Suenjel Skolt Lapps of northeastern Finland, is described in detail by Karl Nickul in 'The Skolt Lapp community Suenjel Sijd during the year 1938', the fifth volume in the Nordic Museum's *Acta Lapponica* series. The handsome format of this publication continues the high standard of the whole series.

The author had originally planned to study the normal adjustment of the isolated Skolt Lapps to western influence, which had been increased in the 1930's as Finland intensified the economic development of her northern territory. Nickul was forced to abandon this project because of the radical disruption of Suenjel Skolt Lapp culture brought about by the Russo-Finnish War of 1939-40, when Skolt territory came within the sphere of military operations, and by the fact that Suenjel has been administered by the U.S.S.R. since the Second World War.[3] This book, based on material collected between 1929 and 1940, records a way of life conservative even for its time and now shattered beyond repair.

Nickul's interest in the Skolts is primarily sociological rather than historical. His purpose is to give a "cross-section of the community in 1938 . . . the last normal year. . ." Accordingly, the book contains minute details as to family area, composition of the households, camping places, extent of nomadism, winter villages, economic life, and demographic and anthropometric information.

The Skolt Lapp culture was unique in several respects. It differed considerably from that of other Lapp groups, especially the Swedish and Norwegian reindeer nomads. Fishing, not reindeer raising, was the Suenjel Skolts' principal means of livelihood. Reindeer herding, hunting, and sheep and cattle rearing were subsidiary occupations. Foreign elements in the culture came from Russian, rather than Scandinavian, sources. While the Scandinavian reindeer nomads have a loosely-knit

[3]Nickul has summarized the effects of these events on the Skolt Lapps in "The Finnish Lapps in wartime and after", *Man*, Vol. 50 (1950) pp. 57-60.

social structure and make decisions by informal methods, the Suenjel Skolts governed themselves by a formal council. Nickul illustrates the operation of this council in a valuable sociological document, the minutes of a meeting at which the Skolts described to Finnish officials their traditional rights and asked that these rights might legally be confirmed.

In spite of the conservative nature of Skolt Lapp culture, it had not remained static. The author, who is vitally interested in culture contact and change phenomena, notes certain tendencies. For instance, we learn that Skolt reindeer breeding had changed somewhat under the influence of Finnish reindeer keepers and that in the 1930's it was a rapidly developing part of the community's economic well-being.

Although Mr. Nickul explicitly abstains from opinions and generalizations, the reader would appreciate them from an astute observer whose long experience with the Suenjel Skolts enables him to speak authoritatively. It would be worthwhile to know, for example, his explanation for such psychological characteristics as the sociability and contented disposition which he found among the Skolts and the reason for the tension which existed between some of the families (see page 52).

Many drawings and 230 superb photographs vividly illustrate the Skolts' mode of living and add considerably to the value of Mr. Nickul's book.

ROBERT N. PEHRSON

THE PROBLEM OF PLACE NAMES IN THE SOVIET ARCTIC

PLACE-NAMES IN THE SOVIET ARCTIC. *By* TERENCE ARMSTRONG. *Polar Record, Vol. 5, No. 39 (1950) pp. 408-426.*

Since the end of the Second World War the rapid growth of Russian studies in the English-speaking world has greatly increased the need for a uniform system for the transliteration of Russian into English. Ideally, it would seem that an efficient system should seek to represent the sound values of the Cyrillic characters by a consistent and conventional use of the Roman. It is desirable not only that the system should be satisfactory for use both in texts and on maps, but should also yield a product which can be pronounced by English readers. In addition it should be possible for the bibliographer to be able to restore a transliterated form correctly to its original.

The problem of devising such a system is complicated, first, by the phonological dissimilarities of Russian and English, and, to an even greater extent, by the vagaries of English phonetics. As a result a very large number of systems are now in use. In more serious literature Mr. Armstrong has counted "at least ten" systems. Since about 1916[1], some effort has been made in England to achieve uniformity in official usage. Mr. Armstrong notes that recent contributions by the Permanent Committee on Geographical Names for British Official Use and by the U.S. Board on Geographic Names hold most promise for the ultimate adoption of a uniform system on both sides of the Atlantic.

The second difficulty which complicates the development of a uniform transliteration system is lexical and grammatical, as opposed to phonetic. Proper names, and, among these, geographical place names, are the words which perhaps most frequently require transliteration. The treatment of foreign place names on maps and in texts is a problem with which geographers have long been vexed. On the peculiarities of Soviet place names, however, no previous literature in English is

[1]The Committee on the Transliteration of Slavonic was established by the British Academy in July 1916; Mr. Armstrong, however, does not appear to refer to its work. (*Proceedings of the British Academy*, Vol. 8, published by the Oxford Univ. Press)

known to the reviewer. Mr. Armstrong has made a material contribution to this aspect of the problem as it appears in the Soviet Arctic.

The difficulties encountered in the treatment of place names in this region are attributed to the varying origins and structures of the names. A few are derived from the languages of the aborigines, for which the Russians have failed to achieve a uniform Russian form. A considerable number are of Western European origin, testifying to English, Dutch, Austrian, Scandinavian, and American exploration of the region. Many of these are difficult to recognize when transliterated back into English. Despite the fact that many post-Revolutionary changes were tidied up by decree, a few places possess alternative names which are still in use, so that it becomes difficult to establish the preferred name. Some features, notably several arctic coastal seas, possess familiar English names as well as those in use in the USSR.

Thus far these difficulties are probably similar to those arising in the treatment in English of the place names of any foreign country. The author has also catalogued, very thoroughly, the peculiarities of Soviet Arctic place names. Like English names, these frequently consist of specific and generic components. In Russian, however, the form, grammatical relationship, and sequence of these components is not uniform. A number of pleonasms occur, and, in many cases, generics, with or without associated specifics, are used on maps to provide "map information" rather than to indicate a place name. From an examination of these idiosyncrasies of structure and usage, the author proceeds to a concise statement of the problems involved in translation and transliteration of these names.

He then surveys the practice of a number of responsible map-makers on both sides of the Atlantic, including the Admiralty and the Directorate of Military Survey in the United Kingdom, and the Army Map Service, the Hydrographic Office, and the American Geographical and National Geographic Societies in the United States. He finds that there is already a tendency to prefer transliteration of the generic parts of place names, and general agreement on the use of English names for coastal seas. On a number of questions, however, considerable differences in policy still exist, and these he examines in detail.

As a basic principle, the author accepts the use of the locally preferred place name. As he points out, the treatment of Soviet Arctic place names which he suggests incorporates those practices which have already secured some measure of agreement. He appears to be somewhat reluctant in his acceptance of the basic transliteration system jointly approved by the P.C.G.N. and the U.S.B.G.N. in 1947; and, indeed, there is room for improvement in this system. The use of certain modifications to the Roman alphabet which have been developed in Czech would eliminate the need to represent these sounds in English by digraphs and reduce the clumsiness of this system on maps. His glossary (of about one hundred and fifty words) is particularly valuable for the definitions of certain terms used only in the Soviet Arctic, the precise connotations of which can be elusive in the more readily available dictionaries.

The author is probably correct in suggesting that it may be possible to apply his system to place names in other regions of the U.S.S.R., and that the adoption of its fundamental principles by the countries of Western Europe might facilitate the international use of documents concerning the U.S.S.R. Should the appropriate organs of UNESCO direct their attention to the problem of the transliteration of Russian into English, they will find in Mr. Armstrong's work an invaluable discussion of the problem which is as constructive as it is competent.

C. J. WEBSTER

REVIEWS

DE GLACIOLOGISKA UNDERSÖKNINGARNA I KEBNEKAJSE 1946-49. (Glaciological studies in Kebnekajse).

By Hans W:son Ahlmann. *Lund; Sweden: Geografisk Arsbok, No. 77 (1950) pp. 106-127. (In Swedish with a summary in English).*

In 1945, when Professor Ahlmann resumed his researches on the glaciers around the Norwegian Sea, he decided to undertake a systematic study of relatively continental glaciers. After a reconnaissance by his assistant, Valter Schytt, he chose the Storglaciär and the Rabots Gläciar in the Kebnekajsemassiv (67°50N.) of Swedish Lapland. The main objective was to study the effect of the modern climatic change on the volume of the glaciers. The field staff was headed by Schytt.

The accumulation of snow was determined with the aid of bamboo stakes, pits, and seismic soundings; the specific gravity of the snow was determined; and the volume of the water was calculated. Since meltwater trickling down into the snow refreezes upon reaching the cold lower strata, and since below the névé limit some meltwater forms superimposed ice, the ablation, or loss by melting and evaporation, is not easily determined. Schytt and his associates therefore dug pits down to the autumn surface of the previous year to determine the water content of the snow at various levels and the thickness of the superimposed ice.

By comparison of old maps with recent maps and photographs the average annual decrease of the Storglaciär during the period 1922-46 was calculated to have been 2.6 million cubic metres of water. In 1946-7 the loss was 6.4 million cubic metres, in 1947-8 the budget was balanced, and in 1948-9 there was a surplus of about 2.8 million cubic metres of water.

The excessive ablation, which ended in 1947, was evidently connected with the climatic change which has gone on for about a hundred years; but whether the large snow surplus in 1948-9 was a temporary reversal of the preceding long trend or is the beginning of an opposite climatic trend, only the future can tell.

Ahlmann himself devoted the summers of 1948 and 1949 to the study of the crystal structure of glacier ice. E. Bergström mapped the numerous glaciers in the Kebnekajsemassiv, their moraines, and the adjacent vegetation belts. In addition meteorological observations were made, and instruments were tested.

Ernst Antevs

NORTHERN NEWS

Aircraft accident at Alert[1]

On 31 July 1950 an R.C.A.F. Lancaster aircraft crashed at the weather station Alert, near Cape Sheridan, north Ellesmere Island, killing Colonel C. J. Hubbard of the United States Weather Bureau, Dr. D. W. Kirk of the Geographical Branch, Department of Mines and Technical Surveys, and the seven members of the crew. The crew were: W/C D. French; F/O T. D. Martin; F/L L. M. Maclean; F/O J. R. Dube; F/L J. F. Swinton; F/O J. E. McCutcheon; and LAC R. L. Sprange.

The Lancaster was one of two, based at Greenwood, N.S., used for long-range ice reconnaissance by the supply mission to the joint Canadian/United States northern weather stations. The aircraft was dropping supplies to the weather station when a parachute caught in the tail assembly causing the aircraft to crash. All the occupants were killed immediately and were buried at Alert. It had been intended that their bodies should be brought out, but a Canso which was sent north for this task hit some ice off the station and was dam-

[1]Reprinted in the main from the *Arctic Circular*, Vol. 3, No. 4 (1950) pp. 46-7.

aged; the crew however escaped safely.

Colonel C. J. Hubbard, a Fellow of the Arctic Institute, was chief of Arctic Projects in the United States Weather Bureau, and at the time of his death was acting as senior U.S.W.B. official on the supply mission. He had had considerable northern experience in the Labrador and during the war in the development of aviation facilities in the Hudson Bay area. He played a major part in the setting up and maintaining of the joint Canadian/United States weather stations in the far north and had been on the 1948 expedition which chose the site for Alert, the most northerly permanent weather station in the world.

Air navigation in high latitudes

When the Royal Air Force Lancaster "Aries" made its series of north polar flights in May 1945, it became the first British Commonwealth aircraft to fly over the North Pole. The main purpose of the flights, however, was to make the first critical test of up-to-date navigation equipment and methods in areas near the North Pole and the North Magnetic Pole, and no less than five navigation specialists from the Empire Air Navigation School at Shawbury, England, were included in the crew.

One of these, Squadron Leader A. J. Hagger, an instructor at the time of the Specialist Course at Shawbury, flew as second pilot, meteorological observer, and photographer. Despite these multifarious duties, he was intimately associated with every aspect of the navigation from the earliest planning stages of the expedition to the final analysis of results, and is exceptionally well qualified to make a critical assessment. In a paper on "Air navigation in high latitudes" in the *Polar Record* (Vol. 5, No. 39, 1950, p. 440-9), Hagger reviews the special problems of polar navigation, treating in detail the difficulties and solutions of definition of direction, methods of steering, methods of fixing, and methods of plotting. Although the manuscript was received for publication in November 1947, it is an excellent summary of the air navigation problems as they exist in high latitudes today, and as they will exist in all likelihood tomorrow.

As is well known a considerable amount of arctic flying has taken place since Hagger's paper was written, including the routine U.S.A.F. weather reconnaissance flights from Fairbanks, Alaska, to the North Pole. A few comments based on this recent experience may therefore be of interest.

The U.S.A.F. and R.C.A.F. navigators use grid directions[1] in high latitude flying, as explained in Hagger's paper, but prefer the 180th meridian as the "grid zero" direction from the pole, rather than the Greenwich meridian. The particular technique of astro compass measurement of aircraft heading, which they have found easiest to employ, requires the transformation of true direction to grid direction each time an observation is made. Using the 180th meridian as reference line, rather than the Greenwich meridian, eliminates the $\pm 180°$ from the arithmetic. The corresponding result that the grid direction of any heavenly body is then 180° different (or nearly so) from its Greenwich Hour Angle, has proved no great disadvantage.

The pilot's uncomfortable feelings, which Hagger experienced, when the navigator changes from true to grid direction, apparently vanish with practice. In fact in many cases the pilot's gyro is not adjusted throughout the flight, the navigator simply recording its error, and giving the pilot gyro headings to steer, rather than true headings or grid headings.

The long twilight of high latitudes, exaggerated often by the aircraft's motion over the earth, is, as mentioned by Hagger, a hazard to be reckoned with, since no heavenly bodies may be visible for direction or position checks for an extensive period. The recently developed Pfund Sky Compass, utilizing polarized light, can measure the direction of the sun when it is below the horizon, and so offset to some extent this difficulty.

Recent arctic flying has built up a considerable wealth of experience of

[1]See "Polar Navigation" in *Arctic*, Vol. 2 (1949) p. 183.

the radar returns from land and water in the Arctic, during all seasons of the year. Maps of northern Canada have also been corrected considerably so that aircraft carrying search radar often find radar fixing of position quite feasible.

Finally, the normal methods of sight reduction are generally used by northern navigators, altitude-azimuth tables now being available from 89°S. to 89°N. But as aircraft speeds increase even these methods seem too slow.

K. C. MACLURE

Waterfowl breeding ground survey in the Ungava Peninsula

In the summer of 1949 Mr. Carl R. Eklund, biologist, with Mr. Leon D. Cool as pilot, investigated the waterfowl breeding grounds of the Ungava Peninsula. Ground studies were made in seven areas within the interior of the Peninsula and seventeen aerial transects, totalling 2476 miles, were flown between June 29 and August 3. The main bases of operation were Fort Chimo and Payne Lake, from which most of the aerial transects were flown. Flying was done with a Fairchild 24 aircraft at an elevation of 150 feet above the ground whenever possible. The principal rivers surveyed were the Payne, North Payne, Leaf, False, Whale, George, Koksoak, Kogaluk, and Povungnituk.

A detailed count was made of the various waterfowl observed. In the interior tundra regions of the area studied the Canada goose and the old-squaw were found to be the most abundant nesting species. Other species which probably nest there occasionally include: American golden-eye, red-breasted merganser and possibly the black duck. The Common eider is abundant in the tidal area along the west side of Ungava Bay and northward to Hudson Strait, while the king eider also probably nests along the Strait in limited numbers. In the taiga region studied the Canada goose and the black duck were the most important nesting species. Next in importance were the golden-eye and the merganser, together with an occasional old-squaw, pintail, scaup, and ring-necked duck.

While there were no heavy concentrations of geese, they were fairly well distributed. The species appears to favour the larger lakes and rivers, with the Whale, Payne, Leaf, and Kogaluk rivers being the most productive. The nesting season was late; all Canada geese observed appeared to have hatched during the first two weeks of July. There was no evidence that predators affect the waterfowl although it is possible that the arctic fox may prey on the nests. As far as could be ascertained weather and water conditions did not seem to be direct limiting factors in the waterfowl productiveness of the area.

British West Greenland Expedition

A British expedition sailed from Copenhagen for West Greenland towards the end of June. The expedition plans to continue the geological investigations on Ubekendt Ø, off Svartenhuk Halvø, carried out by British expeditions in 1938 and 1939, and to initiate glaciological studies on the nearby mainland. Those taking part in 1950 are: H. I. Drever, leader and senior geologist; W. S. MacKenzie, geologist; P. J. Wyllie, glaciologist; T. J. Ransley and C. G. M. Slesser, surveyor-mountaineers; N. S. Tennent, mountaineer and photographer. It is expected that at least four Greenlanders will be employed by the expedition.

The 1938 and 1939 expeditions both established their base camps at Igdlorssuit, on the east coast of the island. A summary of the work of these expeditions was published in *Nature* (Vol. 144, No. 3661 (1939) pp. 1073-1074). Other results have been published in *Meddelelser om Grønland* (Vol. 134, No. 8 (1948) pp. 1-34) and the *Geographical Journal* (Vol. 94 (1939) pp. 388-401).

The 1950 expedition plans to establish a base at Igdlorssuit again and in addition one at Nugatsiaq, on Qequertarssuaq Ø to the northeast. It is thought that three weeks of intensive field work should be sufficient to complete the petrographical examination of Ubekendt Ø begun in 1938-9.

The glaciological work will be carried out from the base at Nugatsiaq. The

Umiamako Isbrae and Rinks Isbrae on the mainland are within easy reach of Nugatsiaq. Both these glaciers are very active and fast moving, and it is hoped that a study of them may provide valuable information on glacier flow. In addition to surveying and making photographic records of these glaciers, the crystallography and texture of the ice will be examined by methods developed by Seligman and Perutz. The geology of the metamorphic complex through which the glaciers flow will be studied for the Danish Geological Survey.

The plans of the expedition have been approved by the Danish Government and the Danish Commission for Scientific Investigations in Greenland. Transportation is being provided by the Grønlands Styrelse.

Award of Bruce Memorial Prize to Dr. M. J. Dunbar

It has recently been announced that Dr. M. J. Dunbar, Associate Professor of Zoology at McGill University and a Governor of the Arctic Institute, has been awarded the Bruce Memorial Prize for 1950 in recognition of his contributions to scientific research in the Arctic. The prize is given in memory of Dr. W. S. Bruce, the Scottish oceanographer who led the Scottish National Antarctic Expedition of 1902-4. The prize consists of a bronze medal and twenty guineas and was awarded by a joint Committee of the Royal Society of Edinburgh, the Royal Physical Society, and the Royal Scottish Geographical Society.

Since 1935 and 1936 when he was a member of the Oxford University expeditions to Greenland Dr. Dunbar has carried out marine investigations in Alaska, Greenland, and the Eastern Canadian Arctic. For the past three years he has been studying Eastern Arctic waters for the Fisheries Research Board of Canada. The purpose of the investigations has been to discover marine resources which might be useful to the natives and to add to the knowledge of the oceanography and hydrography of the area. The *Calanus*, a 49-foot ketch (*Arctic*, Vol. 2 (1949) p. 56), has been built for this work.

Presumed death of Mr. Rodgers D. Hamilton

At midday on 9 May 1950 Mr. Rodgers D. Hamilton and Mr. Burt Galbraith, pilot, left Tigvariak Island in a Norseman aircraft to fly to Point Barrow, Alaska, some 220 miles. The aircraft did not arrive at its destination nor did it report elsewhere. An immediate search was started with Alaska Airlines, who owned the missing aircraft, Wien Airlines, and the Tenth Air-Sea Rescue Squadron, Ladd Air Force Base. This search has been unsuccessful and it is presumed that Mr. Hamilton and the pilot have been killed.

At the time of his disappearance Mr. Hamilton was carrying out field studies on arctic invertebrates under contract with the Johns Hopkins University. In 1948 and 1949 he had received research grants from the Arctic Institute to study the wood frog along the rivers of northern Alaska and the Northwest Territories of Canada.

GEOGRAPHICAL NAMES IN THE CANADIAN NORTH

The Canadian Board on Geographical Names has recently adopted the following names for official use in the Northwest Territories, the Yukon, and northern Quebec. For convenience of reference the names are listed under the respective sheets of the 8 Mile to 1 Inch or 4 Mile to 1 Inch Maps of the National Topographic Series. The latitude and longitude given are approximate only and refer to the first letter of the name except where a precise location is given for a place or a spot height for a mountain.

Coal River, 95 D Yukon and Northwest Territories
(Adopted 1 September 1949)

Camp Creek	60°31N.,	127°21W.	
Contact Creek	60 06	127 45	
Cosh Creek	60 04	127 51	
Dalziel Creek	60 36	127 14	
Gusty Lakes	60 27	126 32	not Gusty Lake
Lootz Creek	60 08	126 58	
Lootz Lake	60 12	126 56	
Otter Creek	60 21	127 19	
Quartz Creek	60 33	127 46	
Quartz Lake	60 32	127 51	
Scoby Creek	60 02	127 37	
Siwash Creek	60 08	126 38	
Tropical Creek	60 06	126 13	

Hudson Strait West, 35 N.W. and 35 N.E. Quebec and Northwest Territories
(Adopted 16 January 1950)

Charles Bay	62°40N.,	74°20W.	

(Adopted 6 July 1950)

Hurin Throughlet	64 00	78 00	now used to designate the channel between Mill Island and the unnamed island to the west. Name not given on the map.
Kugluk Cove	62 21	76 00	
Mount Lansdowne	63 49	72 25	not Lansdowne Mountain
Staffe Islet	62 28	77 48	

Watson Lake, 105 A Yukon
(Adopted 1 September 1949)

Allan Creek	60°34N.,	129°56W.	not Allen Creek
Cabin Creek	60 18	129 07	not Stewart Creek
Dodo Lakes	60 03	129 09	not Dodo Lake
False Canyon Creek	60 42	129 02	
Heigelberg Creek	60 45	129 56	
Heigelberg Lake	60 53	129 51	
Little Jimmy Lake	60 54	129 42	
Marten Lake	60 42	129 23	
Mount Murray	60 54	128 49	not Tent Peak
Oscar Creek	60 43	128 47	not Beaver Creek
Oscar Lake	60 44	128 49	not Beaver Lake
Sambo Creek	60 36	129 32	
Sambo Lake	60 43	129 30	
Stewart Creek	60 34	128 37	
Stewart Lake	60 37	128 38	
Tom Creek	60 18	129 00	
Tom Lake	60 27	128 40	

INDEX

A

Aerial photography, Photographic operations of the Royal Canadian Air Force: R. I. Thomas, 150*
Aerological data for northern Canada: T. J. G. Henry and G. R. Armstrong, 66, *rev. art.*
Aeromedical Laboratory, Fairbanks, 125
Ahlmann, H. W., De glaciologiska undersökningarna i Kebnekajse 1946–49, 191†
Akimiski Id., tidal observations in vicinity of, 95–100
Alaska
  application of tree-ring chronology to archaeology in, 121†
  botanical investigations of parts of the Brooks Range and the Arctic Slope of, 122†
  economic studies in, 124†
  entomological investigations in northern, 122†
  Observations on a cyclic decline of lemmings on Arctic Coast of Alaska, R. Rausch, 166*
  Pribilof Is. seal industry, 75*
  study of cryptogams of Arctic Slope of, 71†
  study of vegetation types in relation to soil profiles in, 70†
  survival ration studies in, 124†
  The reindeer industry in Alaska: M. Lantis, 27*
  trichinosis investigations in, 105*
Alert, aircraft accident at, 191†
Aleutian Is., anthropological investigations in, 122†
Antevs, E., rev. of De glaciologiska undersökningarna i Kebnekajse 1946–49: H. W. Ahlmann, 191†
Anthropology
  application of tree-ring chronology to archaeology in Alaska, 121†
  investigations in Aleutian Is., 122†
Archaeology
  An unusual archaeological specimen from Foxe Basin: G. Rowley, 63*
  Danish Peary Land exped. investigations, 12
  Eskimo stone houses in Foxe Basin: T. H. Manning, 108*
  reconnaissance in southern Labrador and northern Newfoundland, 70†
Arctic Institute
  Baltimore-Washington office, 121†
  bills in Congress, 121†
  Fellows, 72†
  grants awarded for 1950 season, 68†
  photograph collection at Montreal office, 120†
  research reports, 70, 121
Armstrong, G. R., Aerological data for northern Canada, 66, *rev. art.*
Armstrong, T. E., Place-names in the Soviet Arctic, 189, *rev. art.*
Assistance Bay, tidal observations made by *Sophia*, 103–104

B

Baffin Id. exped., 119†, 131*
Baird, P. D.
  Baffin Id. exped., 119†, 131*
  rev. of Franklin of the Arctic: R. S. Lambert, 67†
Banks Id., A biological exploration of Banks and Victoria Is.: A. E. Porsild, 45*

Articles and Papers *
Reviews and Notes †

Bennett, P. M., rev. of Igloo for the night, and A summer on Hudson Bay: Mrs. T. Manning, 117†
Bertram, G. C. L., Pribilof fur seals, 75*
Biology
  A biological exploration of Banks and Victoria Is.: A. E. Porsild, 45*
  Studies of the biology and control of biting flies in northern Canada: C. R. Twinn, 14*
  see also Botany, Zoology, etc.
Black flies, investigations of biology and control of, 17
Blue Dolphin exped., 1950, 120†
Bøgvad, R., Nepheline syenite and iron ore deposits in Greenland, 86*
Botany
  Baffin Id. exped. ecological investigations, 146; lichen investigations, 148
  Danish Peary Land exped. investigations, 8
  investigations of parts of the Brooks Range and Arctic Slope of Alaska, 122†
  investigations in Newfoundland, 122†
  study of cryptogams of the Arctic Slope of Alaska, 71†
  study of vegetation types in Alaska in relation to soil profiles and solifluction, 70†
Brandly, P. J., A preliminary note on trichinosis investigations in Alaska, 105*
British West Greenland exped., 193†
Brooks Range, botanical investigations, 122†
Brown, M., study of peripheral circulation in the Eskimo, 71†
Bruce, W. S., award of Memorial Prize to M. J. Dunbar, 194†

C

Canada
  Photographic operations of the Royal Canadian Air Force: R. I. Thomas, 150*
  Studies of the biology and control of biting flies in northern Canada: C. R. Twinn, 14*
  The upper air over northern Canada: F. K. Hare, 66, *rev. art.*
  work of Geodetic Survey, summer of 1949, 128†
Canadian Board on Geographical Names, decisions on names, 72†, 149, 195†
Churchill, studies of biology and control of biting flies in vicinity of, 14
Climate
  of Peary Land, 11
  observations of Baffin Id. exped., 144
Clyde Inlet, expedition to vicinity of, 119†, 131*
Collinder, B., The Lapps, 187, *rev. art.*
Cryptogams, study of cryptogams of the Arctic Slope of Alaska, 71†

D

Danish Peary Land Exped., 1948–49, A preliminary account: P. C. Winther *et al*, 3*
Dansereau, P., ecological investigations of Baffin Id. exped., 146
Denmark, A preliminary account of the Danish Peary Land exped., 1948–49: P. C. Winther *et al*, 3*
DDT, use in insect control, 19

Dog disease, in Labrador, 1950, 126
Drever, H. I., British West Greenland exped., 193†
Dunbar, M. J.
award of W. S. Bruce Memorial Prize to, 194†
rev. of Exploratory fishing expedition to the northern Bering Sea in June and July, 1949: J. G. Ellson, D. E. Powell, and H. H. Hildebrand, 118†
Dundas Harbour, study of stratigraphy of region of, 123†

E

Eade, K. E., geological reconnaissance of Baffin Id. exped., 137
Ecology, Baffin Id. investigations, 146
Eisberg, H. B., Fundamentals of arctic and cold weather medicine and dentistry, 68†
Eklund, C. R., waterfowl breeding ground survey in Ungava Peninsula, 1949, 193†
Ellson, J. G., Exploratory fishing expedition to the northern Bering Sea in June and July, 1949, 118†
Entomology
investigations in northern Alaska, 122†
investigations in Newfoundland, 122†
Studies of the biology and control of biting flies in northern Canada: C. R. Twinn, 14*
Eskimo
Eskimo stone houses in Foxe Basin: T. H. Manning, 108*
study of peripheral circulation in, 71†
Exploratory fishing expedition to the northern Bering Sea in June and July, 1949: J. G. Ellson, D. E. Powell, and H. H. Hildebrand, 118†

F

Fellows of the Arctic Institute, 72†
Fish and Wildlife Service, U.S.
management of Pribilof fur seal herds, 75–85
northern Bering Sea exped., 1949, 118†
Fisheries, rev. of Exploratory fishing expedition to the northern Bering Sea in June and July, 1949: J. G. Ellson, D. E. Powell, and H. H. Hildebrand, 118†
Flies, Studies of the biology and control of biting flies in northern Canada: C. R. Twinn, 14*
Fouke Fur Company, 79
Foxe Basin
An unusual archaeological specimen from Foxe Basin: G. Rowley, 63*
Eskimo stone houses in Foxe Basin, T. H. Manning, 108*
Fram, drift of, 179
Franklin of the Arctic: R. S. Lambert, 67†
Frazer, J. E., Labrador winter notes, 1950, 126†
Fristrup, B., meteorological and glaciological investigations of Danish Peary Land exped., 9
Fundamentals of arctic and cold weather medicine and dentistry: H. B. Eisberg and J. E. Owens, 68†

G

Geodetic Survey, work in summer of 1949, 128†
Geographical names in northern Canada, 72†, 149, 195†
Geography, investigations in Perry River region, 123†
Geology
Baffin Id. exped. investigations, 137
Danish Peary Land exped. investigations, 6
study of stratigraphy of Dundas Harbour region, 123†
Geomorphology, Baffin Id. exped. investigations, 139
Giddings, J. L., archaeological studies in Bering Strait region, 121†
Glacial-meteorological investigations on the Karsa Glacier in Swedish Lappland 1942–48: C. C. Wallén, 113, *rev. art.*
Glaciology
Baffin Id. exped. investigations, 141
Danish Peary Land exped. investigations, 9
Glacial-meteorological investigations in Swedish Lappland 1942–48: R. P. Sharp, 113, *rev. art.*
rev. of De glaciologiska undersökningarna i Kebnekajse 1946–49, H. W. Ahlmann, 191†
Goldthwait, R. P., geomorphology investigations of Baffin Id. exped., 139
Golovin, reindeer herd at, 41
Greenland
A preliminary account of the Danish Peary Land exped., 1948–49: P. C. Winther *et al*, 3*
British West Greenland exped., 193†
Nepheline syenite and iron ore deposits in Greenland: R. Bøgvad, 86*
Grønnedal, magnetite deposits at, 91, 93

H

Hagger, A. J., air navigation in high latitudes, 192†
Hale, M. E., lichen investigations of Baffin Id. exped., 148
Hamilton, R. D., presumed death of, 194†
Hanson, Harold C., investigations in Perry River region, 123†
Hanson, Herbert C., study of vegetation types in Alaska in relation to soil profiles and solifluction, 70†
Hare, F. K., The upper air over northern Canada, 66, *rev. art.*
Harp, E., archaeological reconnaissance in southern Labrador and northern Newfoundland, 70†
Henry, T. J. G., Aerological data for northern Canada, 66, *rev. art.*
Hildebrand, H. H., Exploratory fishing expedition to the northern Bering Sea in June and July, 1949, 118†
Holmen, K., botanical investigations of Danish Peary Land exped., 8
Hubbard, C. J., death of, 191
Hudson Bay, tides along south Hudson Bay coast, 95*

I

Ice, drift of ice of Polar Basin, 182
Igloo for the night: Mrs. T. Manning, 117†
International Whaling Commission, 77
Iron, Nepheline syenite and iron ore deposits in Greenland: R. Bøgvad, 86*
Isachsen, tidal observations at, 103

J

James Bay, tides along west James Bay coast, 95*

Jeanette, drift of, 178
Johnsen, P., zoological investigations of Danish Peary Land exped., 8

K

Kangerdluarsuk, nepheline syenite deposits at, 86 *et seq.*
Karsa Glacier, glacial-meteorological investigations, 113, *rev. art.*
Knuth, E., archaeological investigations of Danish Peary Land exped., 12
Kranck, E. H., bedrock geology investigations of Baffin Id., exped., 138
Krogerus, H., entomological investigations in Newfoundland, 122†
Kurtz, V. E., study of stratigraphy of Dundas Harbour region, 123†

L

Labrador
  archaeological reconnaissance in southern Labrador, 70†
  Blue Dolphin exped., 1950, 120†
  winter notes, 1950, 126†
Lambert, R. S., Franklin of the Arctic, 67†
Lantis, M., The reindeer industry in Alaska, 27*
Lapps, Recent studies of the Lapps, R. N. Pehrson, 187, *rev. art.*
Learmonth, L. A., discovery of relics from Sir John Ross's exped., 126†
Lemmings, Observations on a cyclic decline of lemmings (*lemmus*) on the Arctic Coast of Alaska during the spring of 1949: R. Rausch, 166*
Lichens, Baffin Id. exped. investigations, 148
Lindroth, C. H., entomological investigations in Newfoundland, 122†
Lipids, study of the role of lipids in the adaptation of animals to various climates, 71†
Llano, G., study of cryptogams of Arctic Slope of Alaska, 71†
Lomen, C. J., reindeer interests in Alaska, 32–35

M

Maclure, K.C., air navigation in high latitudes, 192†
Mandel, W., Some notes on the Soviet Arctic during the past decade, 55*
Manning, Mrs. T., Igloo for the night, and A summer on Hudson Bay, 117†
Manning, T. H.
  Eskimo stone houses in Foxe Basin, 108*
  Notes on the tides along the south Hudson Bay and west James Bay coasts, 95*
Meteorology
  Baffin Id. exped. investigations, 143
  Danish Peary Land exped. investigations, 9
  Glacial-meteorological investigations in Swedish Lappland, 113, *rev. art.*
  The upper air over northern Canada, 66, *rev. art.*
Montgomery, M. R., climate observations of Baffin Id. exped., 144
Mosquitoes, Studies of the biology and control of biting flies in northern Canada: C. R. Twinn, 14*
Musacchia, X. J., study of the role of lipids in the adaptation of animals to various climates, 71†

N

Nain, winter climate, 1949–50, 126
Nansen, F., investigations made by the *Fram*, 179
Navigation, air navigation in high latitudes, 192†
Nepheline syenite and iron ore deposits in Greenland: R. Bøgvad, 86*
Newfoundland
  archaeological reconnaissance of northern, 70†
  entomological and botanical investigations, 122†
Nickul, K., The Skolt Lapp Community Suenjel Sijd during the year 1938, 187, *rev. art.*
Northwest Territories, geographical names in, 72†, 149, 195†
Nunivak Id., reindeer industry, 39
Nutt, D. C., *Blue Dolphin* exped., 1950, 120†
Nuwata, Eskimo stone houses at, 108–109

O

Oblique photography, 154
Oceanography, Physical oceanography of the North Polar Sea, H. U. Sverdrup, 178*
Ornithology
  investigations in Perry River region, 123†
  waterfowl breeding ground survey in Ungava Peninsula, 1949, 193†
Orvig, S., meteorological investigations of Baffin Id., exped., 143
Owens, J. E., Fundamentals of arctic and cold weather medicine and dentistry, 68†

P

Palmén, E., entomological investigations in Newfoundland, 122†
Peary Land, A preliminary account of the Danish Peary Land exped., 1948-49: P. C. Winther *et al*, 3
Pehrson, R. N., Recent studies of the Lapps, 187, *rev. art.*
Perry River, ornithological and geographical investigations in region of, 123†
Photogrammetry, Photographic operations of the Royal Canadian Air Force: R. I. Thomas, 150*
Photography
  collection of photographs at Montreal office of Arctic Institute, 120†
  Photographic operations of the Royal Canadian Air Force: R. I. Thomas, 150*
Physical oceanography of the North Polar Sea, H. U. Sverdrup, 178*
Physiology
  study of peripheral circulation in the Eskimo, 71†
  study of the role of lipids in the adaptation of animals to various climates, 71†
Place names in the Northwest Territories 72†, 149, 195†
Place-names in the Soviet Arctic: T. E. Armstrong, 189, *rev. art.*
Polar Sea, Physical oceanography of the North Polar Sea, H. U. Sverdrup, 178*
Porsild, A. E., A biological exploration of Banks and Victoria Is., 45*
Powell, D. E., Exploratory fishing expedition to the northern Bering Sea in June and July, 1949, 118†

Preliminary account of the Danish Peary Land exped., 1948–49: P. C. Winther *et al*, 3*
Preliminary note on trichinosis investigations in Alaska: P. J. Brandly and R. Rausch, 105*
Pribilof fur seals: G. C. L. Bertram, 75*
Problem of place names in the Soviet Arctic, C. J. Webster, 189, *rev. art.*

Q

Queen's University medical exped. to Southampton Id., 71†
Queneau, P., investigations in Perry River region,123†

R

Rae, R. W., Tidal observations at Resolute Bay and Isachsen, 100*
Rausch, R.
A preliminary note on trichinosis investigations in Alaska, 105*
Observations on a cyclic decline of lemmings (*lemmus*) on the Arctic Coast of Alaska during the spring of 1949, 166*
Recent studies of the Lapps, R. N. Pehrson, 187, *rev. art.*
Reindeer, The reindeer industry in Alaska: M. Lantis, 27*
Resolute Bay, tidal observations at, 100
Riley, G. C., geological reconnaissance of Baffin Id. exped., 137
Rodahl, K., U. S. Air Force survival ration studies in Alaska, 124†
Ross, Sir John, finding of relics from exped. of, 126†
Rowley, G., An unusual archaeological specimen from Foxe Basin, 63*
Royal Canadian Air Force, Photographic operations of,: R. I. Thomas, 150*

S

Scott, P., investigations in Perry River region, 123†
Seals, Pribilof fur seals: G. C. L. Bertram, 75*
Sedov, drift of, 179
Sharp, R. P., Glacial-meteorological investigations in Swedish Lappland, 113, *rev. art.*
Shelesnyak, M. C., resignation of, 121†
Shimkin, D. B., economic studies in Alaska, 124†
Ships
Blue Dolphin exped., 1950, 120†
Fram, 179
Jeanette, 178
Sedov, 179
Sophia, tidal observations made by, 103-104
Victory, 126
Shrinkage of the Karsa Glacier and its probable meteorological causes: C. C. Wallén, 113, *rev. art.*
Skolt Lapp community Suenjel Sijd during the year 1938: K. Nickul, 187, *rev. art.*
Some notes on the Soviet Arctic during the past decade: W. Mandel, 55*
Sophia, tidal observations at Assistance Bay made by, 103–104
Soviet Arctic
Problem of place names in the Soviet Arctic, C. J. Webster, 189, *rev. art.*
Some notes on the Soviet Arctic during the past decade: W. Mandel, 55*
Spetzman, L. A., botanical investigations of parts of the Brooks Range and the Arctic Slope of Alaska, 122†
Summer on Hudson Bay: Mrs. T. Manning, 117†
Survival ration studies in Alaska, 124†
Sverdrup, H. U., Physical oceanography of the North Polar Sea, 178*
Sweden, Glacial-meteorological investigations in Swedish Lappland, 113, *rev. art.*

T

Tabanids, investigations of biology and control of, 18
Thomas, R. I., Photographic operations of the Royal Canadian Air Force, 150*
Tidal observations in arctic waters: T. H. Manning and R. W. Rae, 95*
Tri-camera photography, 153
Trichinosis, investigations in Alaska, 105*
Troelsen, J., geological investigations of Danish Peary Land exped., 6
Tuomikoski, R., botanical investigations in Newfoundland, 122†
Twinn, C. R., Studies of the biology and control of biting flies in northern Canada, 14*

U

Ungava Peninsula, waterfowl breeding ground survey, 1949, 193†
United States
Air Force survival ration studies in Alaska, 124†
Fish and Wildlife Service, management of Pribilof fur seal herds, 75–85; northern Bering Sea exped., 1949, 118†
U.S.S.R.
Problem of place names in the Soviet Arctic, C. J. Webster, 189, *rev. art.*
Some notes on the Soviet Arctic during the past decade: W. Mandel, 55*
Upper air over northern Canada: F. K. Hare, 66, *rev. art.*

V

Vertical photography, 151
Victoria Id., A biological exploration of Banks and Victoria Is.: A. E. Porsild, 45*
Victory, H.M.S., 126

W

Wales, D. B., study of stratigraphy of Dundas Harbour region, 123†
Wallén, C. C., The shrinkage of the Karsa Glacier and its probable meteorological causes, and Glacial-meteorological investigations on the Karsa Glacier in Swedish Lappland 1942–48, 113, *rev. art.*
Ward, W. H., glaciological investigations of Baffin Id. exped., 141
Waterfowl, breeding ground survey in Ungava Peninsula, 1949, 193†
Weather observations of Baffin Id. exped., 143
Weather stations, aircraft accident at Alert, 191†
Weber, N. A., entomological investigations in northern Alaska, 122†
Webster, C. J., Problem of place names in the Soviet Arctic, 189, *rev. art.*
Winther, P. C., A preliminary account of the Danish Peary Land exped., 1948–49, 3*

Z

Zoology, Danish Peary Land exped. investigations, 8

MAPS

ALASKA

Arctic Coast and lemming density, 166
General, 28

CANADA

Air photographic coverage, 152
Baffin Id., Clyde Inlet region, 132–33
Banks and Victoria Is., 46
Foxe Basin, 111
Hudson and James bays, 97
Nichicun Sheet, 23 S.W., before and after air photography, 159

GREENLAND

General, 86
Ivigtut district, 91
Julianehaab district, 87
Peary Land, 4

U.S.S.R.

General, 56

GENERAL

Bathymetric chart of North Polar Sea, 180

ILLUSTRATIONS

ALASKA

Blair Lake, 124, 125
Lemmings, 167, 169, 170, 171, 172, 175
Pribilof fur seals, 74, 76, 78, 80, 81, 82
reindeer, 27, 40

CANADA

aerial cameras, 157
Akimiski Id., 95, 99
archaeological specimen from Foxe Basin, 63, 64, 65
Banks Id., 45, 48, 51, 52
Barnes Ice Cap, 134, 140
Broad Peak, 136, 137
Canso at Ross Bay, 163
Eglinton Fiord, 130
houses at Nuwata, 108, 109
insect control investigations, 14, 16, 17, 18, 19, 20, 21, 22, 24, 25
Kluane Lake area, 154–55
Lancaster on photographic flight, 150
mosaic of air photographs, 164
Norseman refuelling, Sawmill Bay, 162
Piling, 110
Raft River, 98
Resolute Bay, 101
Revoir Pass, 147
Swiss Bay, 135
Victoria Id., 49, 53
Watson Lake area, 153

GREENLAND

Brønlund Fjord, 2, 6, 7, 12
glaciers in Etukussuk Dal, 10
Grønnedal, 92
Herlufsholm Strand, 13
Ivigtut, 91
Kangerdluarsuk Fjord, 88–89, 90

GENERAL

Tulluahui, 127